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TROPICAL AGRICULTURE is published at the Imperial College of Tropical Agriculture St Augustine, Trinidad, West Indies, at the end of the third week of the month preceding the one of issue. Advertisement rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed in signed articles are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

FOREST CONSERVATION.

THE Secretary of State for the Colonies has recently circulated a despatch in which is summarised the progress which has been made during recent years in the various Dependencies in the direction of the preservation of forests from destruction. The despatch includes a foreword by the Director of the Imperial Forestry Institute (Prof. R. S. Troup, D.SC., F.R.S.) on the "Importance of Forest Conservation in our Colonial Empire," with particular reference to the indirect influence which forests can exert on the welfare of a country.

Wood is an everyday article of life, while many other products yielded by the forests—tan stuffs, gums, resins, paper pulp, &c.—are important requisites of modern civilisation; their value is obvious and can be expressed on a cash basis. But it is not as easy, so to assess the value of forests in the effect they frequently have in regulating water supply, in preventing erosion, in fixing mobile sands, and as windbreaks, and bird sanctuaries, &c. In many cases, they are, in fact, invaluable through the vital influence they have on the community as a whole. That forests form most efficient windbreaks, needs no discussion; that erosion frequently follows on the clearing of hill forests has been observed times without number: but the much debated, but ever fresh, subject of forests and rainfall is not so easily settled. The interplay of the various forces, which culminate in a shower of rain in a specific area, is so complex that up till now, it has not been feasible to secure direct evidence of a critical nature that forests increase the rainfall of a country. In the absence of direct proof, however, it is possible to consider indirect evidence which leads, if not to definite conclusions, at all events to inferences.

Rain is produced when moist air ascends into cooler altitudes—the expansion of the air in a more rarefied environment being itself a factor in lowering the temperature. Lowering the temperature increases the relative humidity to saturation point and the next stage is rain. To consider the effect of forests on rainfall it is therefore necessary to consider the two factors of temperature and humidity.

Observations have shown that forests tend to lower the mean temperature. These effects are communicated to a short distance only outside the forest, and are therefore of somewhat local importance except in a heavily wooded country. The relative humidity of the air is higher in the

forest than in the open, the increase being usually from 4 to 10 per cent., sometimes slightly more. This is due to two causes: firstly the mean temperature of the air is lower in the forest than in the open, and the saturation point is thus lowered; secondly, transpiration from the leaves increases the moisture content of the air. Balloon observations over the Forest of Orleans in France have shown that greater humidity and lower temperature prevail over the forest than over the surrounding open country, the effect being observable up to an altitude of over 5,000 feet.

Reverting to the question of temperature, it is of interest to consider the effect in a mountainous country of a moisture laden breeze striking respectively a bare, and a forest clad slope. In both cases the breeze is forced upwards, but a bare slope may be so heated by the sun that the ascending air is heated and further removed from saturation point, whereas a forest clad slope would tend to exert a relatively cooling influence as well as helping to increase the humidity.

From the evidence considered there seems to be a *prima facie* case for inferring that forests, of certain types at all events, by increasing atmospheric moisture tend to produce rainfall. Whether the precipitation occurs locally or at a distance—through the moisture laden air being conveyed elsewhere by winds—must depend on other factors. In short, the evidence at our disposal leads to the conclusion that forests under special conditions, may be a contributory factor in causing local precipitation, but only in conjunction with other much more powerful factors.

It is generally accepted that in hilly country forests exert a powerful influence in regulating the water supply. This is so well recognised that the maintenance, or creation, of forests in catchment areas in hilly country usually plays a prominent part in any well concerned scheme for the water supply of towns. Recent work by Engler and Burger points to the fact that it is not so much the humus (as was formerly believed) which acts beneficially, as the soil itself, in that the forest soil, through many reasons, is more porous than the more compact soils of the open. This is of special interest in the tropics where soils are, as a rule, devoid of spongy humus. It is probable that forests and field crops tend to diminish the total amount of water supplied to streams, as compared with bare land. But floods during the rains and dry water courses in the dry season are not of much use where a regular and perennial water supply is required. It is the seepage of water into forest soils, later to be given out as springs, which makes a forest cover of such controlling importance.

The effectiveness of forest growth in preventing erosion on steep hillsides, particularly with loose soil, is due mainly to the binding action of the tree roots and the reduction of the erosive action of run off water. The effects of erosion are cumulative, and great caution should be exercised before forest growth is cleared from steep hillsides.

On level country forests have a draining action on the soil, owing to the absorption of water by the roots and its transpiration through the leaves. The writer has frequently observed in Trinidad, that flat areas, with any tendency to swampiness, become far more swampy after the clearing of the forest. An instance of historical importance is to be found in the Landes in south-western France, where afforestation resulted in the drying up of swamps, whereas, extensive clearings made during the war, resulted in a rise of the subsoil water, with a return to swampy conditions. This points to the advisability of exercising great caution in clearing forest growth on ground with any tendency to swampiness. The draining effect of forest growth is often insufficiently appreciated and needs to be emphasised.

In districts exposed to wind the maintenance—or creation—of shelter belts of forest may be essential to successful agriculture. Cocoa for instance, is a crop, for which thorough protection from wind is found to be a controlling factor, both on the Gold Coast, and in Trinidad. Observations at Waggon Wheel Gap, Colorado have shown that the clearance of a wooded area of 200 acres resulted in the wind velocity increasing by 260 per cent.—comparative observations being made for 8 years before clearing and 7 years after clearing. In the Northern Provinces in Nigeria, abutting on the Sahara, the maintenance of forest is of great importance both as a protection from the hot winds from the desert, and from sand encroachment, the destruction of forests results in the approach of xerophytic conditions from the north.

In the case cited above the effect is particularly noticeable owing to the proximity of the Sahara. But, in general, the destruction of forest in the tropics is followed by the growth of a retrograde form of "bush" of a poorer type than that of the original forest. If this takes place over a large area—as may happen in the case of uncontrolled shifting cultivation—it can result in changing the type of vegetation from that of a moist rain forest to that of a deciduous or semi-deciduous type.

A child may be the product of the environment in which it was born but equally it can, by its influence, in due course affect the environment. Forests likewise can re-act and affect the climate of a country. And although forests may not be the panacea for all climatic ills they have in most cases a very important rôle to play in the development of our colonial resources.

Forests reserved primarily for protective purposes need not necessarily be a burden on the finances of the country. In fact, if they are properly managed and brought into full productivity, they are often a source of profit. The reservation of protection forests is, however, only one of the many problems with which forestry, is concerned as will be gathered from a summary of the results of the Third British Empire Forestry Conference which is published in this issue.

PASTURE RESEARCH.

Recent Pasture Research in Great Britain.

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THE complaint has often been heard in the past that grassland farming has scarcely received the same amount of attention at the hands of the scientific worker as has the subject of arable farming, despite the fact that the production of meat and milk has always figured so prominently in British farming. Be that as it may, the complaint can hardly be made with justice at the present time. The pioneer work of such well-known grassland investigators as Somerville, Gilchrist, Hall, Russell and Armstrong has been followed up and extended during the present decade in a series of investigations which have been prosecuted at certain centres for agricultural teaching and research throughout Great Britain. Curiously enough, this epoch of grassland research has coincided with a tendency on the farmer's part to restrict somewhat his interest in corn growing in favour of grassland husbandry, a change of policy which has, however, been dictated purely by economic considerations.

In citing the various lines of recent agricultural research, one need only refer to the investigations into the mineral composition of the herbage from different types of grassland (Rowett Research Institute, Aberdeen); the studies of the pasture attributes of the individual species of grasses (Welsh Plant Breeding Institute, Aberdeen); the work in connection with the composition, digestibility and nutritive value of pasture herbage under different systems of grazing (School of Agriculture, Cambridge). The important investigations of Imperial Chemical Industries, Ltd. into the questions of sectional grazing and the fertilising of pastures should also receive special mention at this point. It is perhaps too early to forecast the ultimate effect on grassland husbandry of all the information which is steadily being accumulated in these different investigations, although it has already become apparent that present methods are by no means adapted to securing the fullest possible advantages which both pasture and meadow are capable of yielding. It will be surprising if the next few years do not witness a number of fundamental innovations in the methods of grassland husbandry throughout the Empire.

Composition and Nutritive Value of Pasture Herbage.

The problem of securing information concerning the feeding value of pasture herbage under conditions resembling those of grazing was attacked at Cambridge in the following manner. At the beginning of the 1925 season, a large plot was marked out on one of the pastures of the University Farm. This main plot was further divided into seven equal sub-plots, and every day throughout the grazing season, one sub-plot was cut over by means of a 16-inch motor lawn mower. In this way the whole plot was cut over once per week throughout the season. After cutting, the grass was left as short as it might be left after being grazed by sheep under conditions of heavy stocking.

It should be noted, therefore, that in this initial trial the system of cutting was frequent and severe. The conditions were so designed as to bring out the results which would be obtained in respect of composition and nutritive value under a system of uniform and close grazing. In subsequent trials, the interval between successive cuttings was lengthened to a fortnight, 3 weeks, and so on, and the influence of these more lenient systems of cutting on the yield, composition and feeding value of the herbage was investigated.

The results of the 1925 investigation may briefly be summarised as follows: pasture grass kept short by efficient grazing contains a very high percentage of protein *throughout the whole season*. Roughly one quarter of the dry substance in such herbage consists of protein, an amount 2½ times as great as that found in grass which has been allowed to grow unchecked for hay. On the other hand, the amount of fibre in such young pasture grass is very much smaller than that in meadow hay. In respect of digestibility, young leafy pasturage compares favourably with a concentrate like linseed cake, being superior to that of a concentrate like palm kernel cake and very much superior to that of best quality meadow hay. Even the fibrous constituent, which in hay is often woody and of low digestibility, is, in pasture grass, digested to an extent almost equal to that of the carbohydrate fraction.

The Cambridge feeding trials have demonstrated that pasture grass possesses a far higher nutritive value than has hitherto been suspected. In its young leafy condition, its dry food material partakes of the character of a protein concentrate like linseed cake and not of a coarse fodder like hay. Unlike many farm concentrates, it is capable of supplying all the animal's requirements for vitamins and for bone and milk-farming minerals like lime, potash and phosphate. It was not without reason, therefore, that the conclusion was drawn "that the farmer's cheapest, and possibly his best concentrate is to be found growing within reach of the homestead." Young leafy pasturage is essentially a feeding stuff designed for production rather than for maintenance purposes.

It is customary to assume that the nutritive value of pasture, and its content of protein, are relatively low in summer and autumn, but this statement is certainly not in accord with the results of the Cambridge work. The feeding value was highest during the spring flush of grass and fell off slightly during mid-season as a consequence of the droughty conditions then prevailing. With the coming of rain, however, the nutritive value gradually recovered, until in September and October the grass was very little inferior in this respect to that available in spring,

At this late stage of the season, the dry matter of the herbage contained no less than 28 per cent. of protein. This result is all the more interesting in view of the fact that the bulk of the herbage at the end of the season consisted of creeping bent, which is usually looked on as possessing poor feeding value.

There can be little doubt, therefore, that it is possible to maintain the nutritive value of pasturage throughout the entire season provided the herbage is adequately grazed. If, as is commonly the case, the pasture is only scantily grazed during late summer, then grasses like bent grass will grow mature and fibrous and of greatly diminished feeding value. The occasional use of the mower is to be recommended, where it is found impossible, by grazing alone, to keep the pasture herbage young and leafy.

In a second investigation carried out during the season of 1926 it was demonstrated that the richness of pasture grass in respect of digestible protein and starch equivalent, is under a system of close-grazing, independent of the botanical character of the herbage or the presence of little or much wild clover in the pasture. This is a finding of the most fundamental significance. It is difficult to resist the conclusion that the botanical composition of a pasture is of secondary importance, and that management, involving not only efficient stocking and close-grazing, but also adequate manuring to ensure density of herbage and vigour of growth, is the primary factor determining the nutritive value of pastures. Botanically, it is desirable that a pasture should contain a number of different species of grasses of different seasons of luxuriance in order to ensure a continuous succession of growths from early spring to late autumn. That factor complied with, it is merely necessary, in order to ensure the best results from the nutritional standpoint, to concentrate on preventing the grasses from flowering and seeding. Should the herbage be permitted to grow long and mature, as on poorly grazed pasture or under meadow conditions, there can be little doubt that the different species would display differing feeding values, and under such conditions the nutritive value would be likely to be conditioned by botanical composition. Under pasture conditions, however, it should be possible in large measure to overcome handicaps from the botanical standpoint by combining a system of close grazing with an intelligent system of fertilising.

Rotational or Sectional Grazing of Pastures.

It is easier to achieve the object of close-grazing with small rather than with big pastures, and for that reason there is a strong movement among British graziers in the direction of dividing up the extensive poorly-grazed pastures into enclosures of much smaller dimensions. The following brief outline of an experiment carried out during 1926 in Yorkshire under the auspices of Imperial Chemical Industries, Ltd., may be taken as typical of the experiences of farmers who have adopted the practice of the rotational grazing of pastures combined with intensive fertilising.

Two large pastures comprising 27 acres were divided into 6 paddocks varying in size from 4 to 5 acres each, with water laid on. In the previous December, the whole of the grassland received a suitable dressing of chalk, phosphate and potash. At the beginning of February, the first enclosure received sulphate of ammonia at the rate of 1 cwt. per acre, and at intervals of about a fortnight similar amounts of this nitrogenous fertiliser were applied in turn to the other enclosures. When the herbage on the first field was 4 to 5 inches long, a suitable head of stock was moved on to it for some days until the field was grazed *uniformly close*. The animals were then moved on to the second field, the first being harrowed and rested for a time.

In this manner the fields were grazed in rotation, the animals feeding on a succession of grass flushes of high nutritive value. After the cycle was complete, the procedure was recommenced, sulphate of ammonia being again applied at intervals to the plots to ensure a succession of flushes of grass. By the application of these arable methods to grassland, it is claimed that not only do the stock secure the herbage in a young and highly nutritious condition, but that the carrying capacity of a pasture may be doubled or even trebled. As a result of the early application of nitrogen, the grass makes sufficient growth for the stock to be turned out by the middle of March, this "early bite" leading to a considerable reduction in the expenditure on concentrated foods.

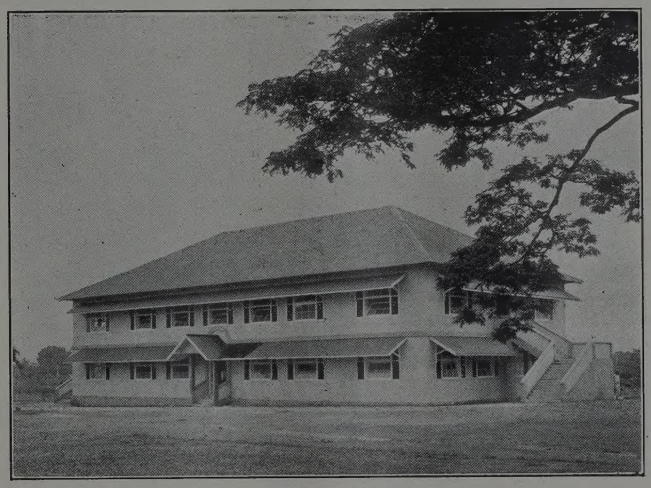
The use of nitrogenous fertilisers on pastures provides the farmer with a method for converting a cheap form of nitrogen into valuable and highly digestible protein. The processes which occur during the growth of the grass, however, demand that the herbage should be held in check by efficient grazing if its high feeding value is to be retained. The intensive production of grass by the aid of fertilisers requires, therefore, the possession of a sufficient head of stock to keep the pastures closely and uniformly grazed. Unfortunately, many farmers at the present time lack the capital for purchasing the extra stock required for this purpose. The alternative, however, is to carry on with the usual number of animals and to reserve the surplus grass for cutting at periodic intervals, such mown grass to be preserved for winter feeding as a source of digestible protein.

Conservation of the Produce of Pastures.

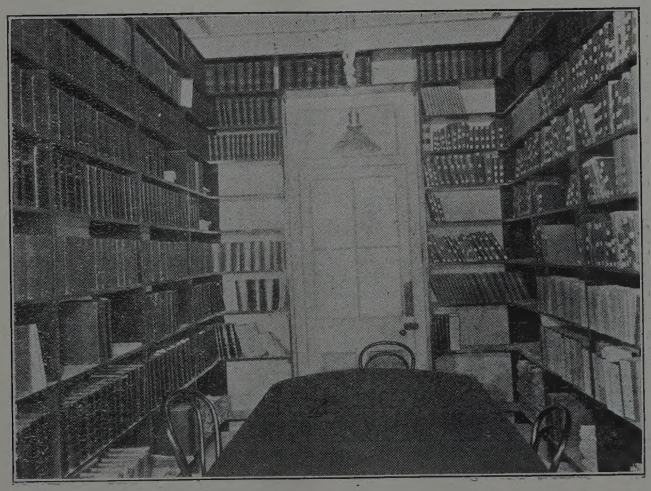
With the recognition of the protein-concentrated character of young leafy pasturage, it was but natural that suggestions should be put forward for the conservation of the surplus produce of pastures for feeding during winter as a protein concentrate. When publishing the results of the earlier Cambridge trials, the writer ventured to

NEW CHEMISTRY BUILDING.

(*See* page 359.)



Exterior view of new Chemistry Building.



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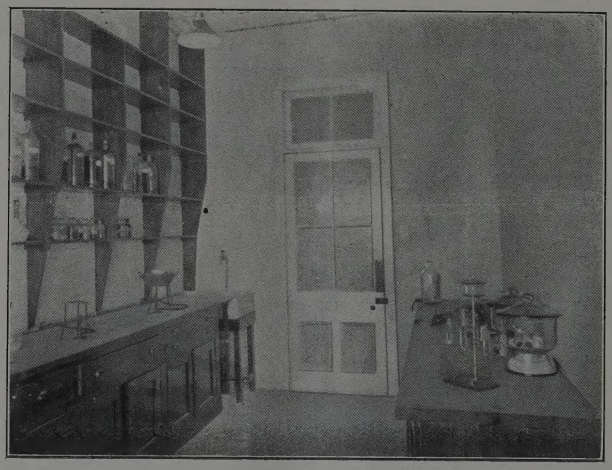
NEW CHEMISTRY BUILDING.



Post-Graduate Students' Research Laboratory.

Diploma Students' Laboratory.

make the following prediction: "A future generation may witness the utilisation of large areas of grassland for the sole purpose of production of protein concentrate. Pastures, having the appearance of vast lawns, may be cut over regularly and frequently throughout the growing season, the nutritious, protein-rich produce being preserved for feeding to animals in winter confinement, along with balancing home-grown feeding stuffs like meadow hay, cereals and roots. The mode of preservation may either be artificial drying, followed by pressing into cakes or grinding to the roughly powdered form, or it may consist in ensiling the freshly cut grass."

During the 1927 season, Imperial Chemical Industries, Ltd., collaborating with the School of Agriculture, undertook the systematic cutting of some acres of grassland in the vicinity of their factory at Billingham. The cutting was so regulated that the herbage was always taken in its young leafy condition. Soon after cutting, the grass was dried down in steam-heated troughs, and later the dried product was compressed into cakes by hydraulic presses. These dried grass cakes measured 6 inches by 5 inches by 1 inch, and were of such a density that 40 cubic feet of the compressed material weighed 1 ton. They had kept the green colour of the fresh grass and had a pleasant fragrant smell. They contained 8 per cent. moisture and 25 per cent. of protein. When moistened with water, they swelled up considerably and disintegrated. Sheep, bullocks and dairy cows ate them eagerly, both in their dry and soaked conditions. It is of interest to record that samples of these dried grass cakes have been kept for more than 2 years in an open box under laboratory conditions without displaying any deterioration whatsoever in respect of colour and smell. Their moisture content is still in the neighbourhood of 8 per cent.

Critical feeding tests on these dried grass cakes were made at Cambridge, and two mainconclusions were drawn: (1) The process of drying does not in any way impair the high nutritive properties of the fresh grass. (2) The dried grass cakes can successfully replace oil cakes in the winter rations of dairy cows and fattening bullocks. It is permissible to hope, therefore, that dried grass cakes will shortly find their way on to the agricultural market and be used as a substitute for oil cakes in the winter rations of farm animals. The problem of devising suitable appliances for cutting and drying down young grass is being studied by Imperial Chemical Industries, Ltd., who are looking forward to placing the process on a commercial footing during the season of 1930.

The advantages of such a side-line in grassland husbandry are manifold: (1) Dried grass cake is an almost ideal concentrated food for farm stock. It is highly digestible and is rich in protein, lime, potash, phosphate, vitamins and plant pigments. Pasture grass conservation implies a 12, instead of a 5 months' pasture season. (2) On the basis of the 1928 winter prices, 1 ton of dried grass cake would be worth £9 15s. for its feeding value alone. It would also have a high manurial value of about 27s. per ton, compared with linseed cake at 31s. and maize meal at 11s. per ton. (3) The advantages of such a system of grass conservation during war time are so obvious as to need no emphasis. During the Great War, one of the most acute problems was to find protein concentrates for farm animals. This difficulty need never arise again, since now it is recognised that the farmer's best protein-concentrated food can be grown on his own farm. Further, the system enables the cuttings from playing fields and sports fields to be usefully conserved. (4) Grass conservation should prove an incalculable boon to droughty parts of the Empire like Australia, where the herbage shrivels away to nothing during bad seasons, and thousands of sheep perish miserably. Why should not the irrigation areas of Australia be used for the intensive growth of young grass to be continually dried and pressed into cakes for transport to the less fortunate droughty regions? Grass cakes will keep for years and are an ideal form for storage and transport. The day may be envisaged when they will be transported between colony and colony and favoured regions will produce them for transport to the more needy parts of the Empire. (5) By grass conservation it will be possible to augment very considerably the available supplies of concentrated feeding stuffs, the shortage of which at present not only prevents the attainment of an all-round standard of intensive animal husbandry in Great Britain, but also causes the high prices ruling for oil cakes and cereal foods.

It is clear that the artificial drying of young grass must always remain an industrial, or semi-industrial process. For that reason, the method of ensilage is likely to make a more direct appeal to the farmer. It is of interest to record that satisfactory tests have been carried out in this connection at Cambridge. Three small silos were filled respectively with grass cuttings from certain college playing fields; with a mixture of grass cuttings and dried sugar beet pulp; with a mixture of grass cuttings and oat straw chaff. The results were satisfactory in every case, the silage being readily eaten by stock. This side of the problem of grass conservation, however, is being studied further at the present time.

The Yield of Pastures.

A third investigation carried out at Cambridge during 1927 showed that the differences in chemical composition, both organic and inorganic, between grass cut at weekly and fortnightly intervals are inconsiderable. The dry matter of grass grown under a system of fortnightly cutting is a protein concentrate equal in digestibility and nutritive value to that obtained by weekly cutting. Moreover, by systematic cutting at fortnightly intervals, these characteristics are retained over the entire season.

During the season of 1928, the work was carried a stage further by the adoption of a system of cutting at intervals of 3 weeks. Though the

herbage obtained under this more lenient system of cutting was somewhat less rich in digestible protein, it was nevertheless equal in respect of digestibility and nutritive value to grass grown under systems of weekly or fortnightly cutting. At the end of three weeks' unchecked growth, pasture grass still consists of non-lignified, highly digestible tissue as at the end of a week's or of a fortnight's growth. Although the protein content of the grass shows a slight falling off during the third week of growth, this is unaccompanied by any corresponding diminution in digestibility. It was further demonstrated that the depressing influence of drought on the protein content and digestibility of pasture grass is much less marked under a system of 3-weekly cutting than under the severer system of cutting every week.

During the carrying out of the 1927 investigation, it was found that if adjoining plots on a pasture be cut at weekly and fortnightly intervals respectively, then the plot cut fortnightly yields somewhat more heavily than the plot cut every week. Further, this disparity in productivity becomes most marked at those times of the season when the conditions for growth are most unfavourable, as, for instance, during a spell of droughty weather. Since the weather conditions of 1928 were, on the whole, unfavourable to the abundant growth of herbage on pastures (owing to droughty conditions which prevailed during April, July and September), it would be anticipated that the yields from the plots submitted respectively to weekly, fortnightly and 3-weekly systems of cutting would display unusually striking differences. That this was actually the case is made clear by the accompanying table, in which a comparison is given of the total yields of herbage, in dry matter per acre, which were obtained in 1928 from the respective pasture plots. The yields from the same pasture under the conditions of the 1925 and 1927 investigations are also given.

Summary of Total Yields from Pasture Plot in three different Seasons of Experiment.

13th April to beginning of October.	Dry matter per acre. Lb.	Dry matter per acre. Lb.	Dry matter per acre. Lb.
	1925.	**1927.**	**1928.**
Weekly cutting ..	2,833	—	1,982
Fortnightly cutting ..	—	3,621	2,562
Three-weekly cutting ..	—	—	3,216

It will be noted that under the weather conditions of the grazing season of 1928, cutting at fortnightly intervals produced 29.3 per cent. more dry matter than was obtained under a system of weekly cuts, whilst the yield obtained by cutting at 3-weekly intervals was 62.3 per cent. greater than that obtained by weekly cutting and 25.5 per cent. greater than that grown under a fortnightly cutting system. Since there is little or no difference, from the standpoint of starch equivalent, between pasture herbage grown under systems of weekly, fortnightly and 3-weekly cuts, the *yield* differences under the 3 systems are possessed of great practical significance. A system of weekly cutting is comparable with the system of grazing where it is the custom of the grazier to regulate the stocking of his sheep-grazing land in such a manner as to keep the herbage uniformly grazed down throughout the grass season. If the herbage shows any tendency to grow beyond the very young stage, more sheep are introduced to hold it in check. This practice may be referred to, for convenience, as "non-rotational close-grazing." On the other hand, a system of 3-weekly cuts may be taken as conforming with the conditions of rotational grazing, where the interval between successive close-grazing of enclosures is of 3 weeks' duration. It will be convenient, for the purposes of the present discussion, to refer to such a system as a "3-weeks' rotational close-grazing system."

The yield results bring to light an important advantage which "rotational close-grazing" possesses over a system of "non-rotational close-grazing." If the pasture, on which these investigations have been carried out, had been so stocked during 1928 that the herbage was kept closely and uniformly grazed down throughout the season, then it would have produced herbage, for the sustenance of the animals, at the rate of about 1,980 lb. of dry matter per acre over the season. If, on the other hand, the tract of grass had been divided up into smaller areas in such a way that each enclosure, after being closely grazed by stock, was permitted a 3-weeks' interval of unchecked growth before being grazed down again, the pasture would have produced herbage at the rate of 3,220 lb. of dry matter per acre over the season. In other words, the stock-carrying capacity of such *unfertilised* pasture would have been increased in the ratio of 198 : 322 (*i.e.*, roughly 2 : 3). This measure of improvement naturally applies only to the pasture under investigation, under the weather conditions of 1928, and would probably not be so marked in a season more favourable to the abundant growth of herbage. Obviously, the question of the maximum yield of digestible food from a pasture is bound up with the investigation of the process of lignification in the herbage, since it is reasonable to assume that the conditions for such maximum yield will be realised when the interval between successive cuttings, or grazings, is as long as possible. The length of this interval will naturally depend on the time required by the young shoots of grass to reach the stage of growth at which lignification, with consequent running-off of digestibility, sets in.

The yield data possess further practical significance in relation to the proposals which have been put forward for conserving pasture

herbage. Before adopting such proposals, it would be necessary to decide the frequency with which the grass should be cut during the growing season. From the standpoints of digestibility and starch equivalent, it is immaterial whether the herbage is cut at weekly, fortnightly or 3-weekly intervals. Under the 3-weekly system, however, the season's yield of herbage will be greater than will be obtained by cutting at shorter intervals, and the difference will be accentuated during seasons when the conditions are not favourable to growth of grass. In regard to protein content, the average figure, on the dry matter basis, for weekly-cut grass will be about 25 per cent., that for fortnightly-cut grass about 23.5 per cent., and that for 3-weekly-cut grass about 21 per cent. It is hoped to secure similar information concerning grass cut at monthly intervals during the 1929 season.

The data from these investigations also serve to demonstrate the *primary* importance of the influence of the general weather conditions of the season (in particular, those of rainfall) on the growth of pasturage. Within the limits of the systems of cutting which have so far been investigated, it is clear that unfavourable meteorological conditions in a particular season may lead not merely to a much smaller growth of grass than would be obtained, under the same system of cutting, in a more favourable year, but may actually cause the yield under a lenient system of cutting to be smaller, instead of larger, than under a less lenient system of cutting during a more favourable season.

Supplementary Feeding on Pastures.

Certain very important consequences follow from the richness of young pasture grass in respect of digestible protein. Under conditions of intensive grazing, pasture herbage constitutes an unbalanced food for all classes of live-stock, not only for fattening animals, but also for classes of stock which make considerable demands for digestible protein in their rations, namely, young growing stock and dairy cattle. One or two examples will serve to make this point clear.

A ration of young spring grass containing 30 lb. of dry matter (that is, the amount of dry matter usually assumed to be the measure of the appetite of a 12 cwt. dairy cow) will supply, on the basis of the Cambridge figures, sufficient digestible protein to satisfy the requirements of a dairy animal yielding as much as 9 gallons of milk per day.

It may be assumed that the ideal ration for a young animal going out on to pasture will be one which approximates most closely to milk in respect of nutritive ratio and lime-phosphate ratio. The Cambridge results show that such a ration is obtained when 9 parts of fresh young pasture herbage are mixed with 1 part by weight of maize meal.

A fattening sheep of about 120 lb. live weight requires no more than $\frac{1}{4}$ lb. of digestible protein in its daily ration. Such an animal, when grazing freely on young spring pasturage will consume rather less than 4 lb. of dry matter per day, including, according to the Cambridge data, about $\frac{4}{5}$ lb. of digestible protein. In other words, the animal is receiving more than three times the amount of digestible protein requisite for its maintenance and production purposes.

It follows, therefore, that the time-honoured practice of using linseed cake, cotton cake or other protein concentrates as supplementary food for pasturing stock is not in accord with the results of the Cambridge investigations. On well-managed pasture, animals should receive, as supplementary food, feeding stuffs which are rich in carbohydrate and poor in protein, such as maize, flaked maize, maize germ cubes, barley, wheat, locust bean meal, sugar beet pulp, meadow hay, &c. Indeed, it appears justifiable to conclude that the optimum results are not possible on closely grazed pasturage with any class of stock, young growing stock, dairy cattle and fattening animals alike, unless such animals are receiving, at all stages of the season, some supplementary food which is richer in carbohydrate.

Minerals in Pastures.

The Cambridge investigations have amply demonstrated that young leafy pasturage is capable, in itself, of supplying the requirements of farm animals for bone and milk-forming minerals. In dealing with the problems of the nutrition of animals on *cultivated* pasture, the question of mineral deficiency can rarely arise. With the exception of milk, no feeding stuff on the farm is better balanced in respect of minerals than pasture grass. There are, however, vast tracts of *uncultivated* pasture in the British Isles and throughout the Empire where this statement is by no means true. Our knowledge of the occurrence of mineral deficiency in the herbage of such wide-spread pastoral areas has been brought together in a recent publication ("Minerals in Pastures," J. B. Orr, 1929, H. K. Lewis & Co., Ltd., London). This treatise is primarily the outcome of the deliberations of a sub-committee appointed in 1926 by the Civil Research Committee of the Cabinet to consider and report on the relationship between the mineral content of pastures and their nutritive value. From the initial enquiries instituted by this sub-committee, it was evident that malnutrition in cattle and sheep arising from deficiency of minerals in grass was quite common in many pastoral districts of the Empire, and that the subject, which was of great economic significance, warranted close and systematic investigation.

A report to this effect was duly forwarded to the Civil Research Committee, on whose further recommendation grants were made by the Empire Marketing Board in aid of a comprehensive scheme of investigations into the mineral aspects of pastures, within the Empire. A twofold scheme of work was adopted, actual investigations in selected grassland areas being supplemented by a detailed search of the literature dealing with every phase of the subject. Major Elliot states

in the preface to the volume: "At the request of the sub-committee the information so far obtained has been brought together by Dr. Orr in the present review, with the object of having it circulated to various officials and research workers throughout the Empire who are interested in the subject."

Beginning with an explanation of the economic importance of grassland, the author passes on to trace the development of scientific methods for investigating the problems of pastures. This is followed by a minute survey of the results of many investigations into the mineral composition of both good and poor pastures in the British Isles and in various parts of the world. The factors which affect the mineral content of pastures are also considered in the light of present knowledge. Dr. Orr then proceeds to deal with various forms of disease which are attributable to deficiency of minerals in pasture herbage. The deficiency diseases of grazing animals in Europe, Africa, Australasia, America and Asia are described in separate chapters, and the results of investigations into the causes of such diseases are summarised and critically discussed. A further chapter treats of the prevention of deficiency diseases of pasturing stock, either by the direct administration to the animal of the deficient minerals or by the enrichment of the pastures through the application of mineral fertilisers to the soil. It is shown that the prevention of disease by these measures also leads to an increased rate of growth in animals and to an increased production in adult females.

The question may be raised, however, as to whether the failure of animals to thrive on these deficient pastoral areas may not frequently be due as much to the *energy-deficient* character of the herbage as to its deficiency in minerals. The starch value of such herbage may be so low that animals, even when consuming it to the limit of appetite, may not be able to secure sufficient *net* energy to permit of normal development. This aspect of the problem is being investigated at Cambridge at the present time.

AGRICULTURE IN MAURITIUS.

January to June, 1929—Progress Report.

Weather Conditions.

The growing season from November, 1928, to the end of June, 1929 was, upon the whole, below normal from an agricultural point of view. Temperature was in defect from November to the end of February and practically normal afterwards, except in May, when a marked excess was in evidence.

Rainfall was generally short from November to January; in February and March, the defect in that element developed into a pronounced drought. Cyclones kept at a distance from the Island.

Sugar Industry.

The preliminary forecast of sugar production for 1929-30, issued at the end of May indicated a probable turn out of 223,000 metric tons, *i.e.*, a reduction of about 12 per cent. on last year's production. Present prospects, however, point to production somewhat in excess of the original forecast and is placed in the neighbourhood of 230,000 tons.

The market for sugar remained low. There was some indication of improvement towards the end of June but, upon the whole, conditions in this respect, are not satisfactory. About 112,000 tons of the forthcoming outturn, of which 100,000 tons of Raws have been sold at an average of Rs. 7.30 net, approximately, per 50 Kilos.

In view of the unsatisfactory financial position of many local sugar concerns, the Chamber of Agriculture is advocating a loan from the Imperial Government of about 20,000,000 rupees, repayable in 20 or 30 years, with low interests. A loan of Rs. 6,000,000, raised in part locally, has been distributed to sugar growers to meet immediate needs.

The organisation of a Research Station, adjoined to the Mauritius Agricultural College, has received official sanction and steps are being taken to assure the financial position of the new venture. Expenses in this connection are estimated at about Rs. 50,000 per annum.

As a result of the return of the Irrigation Officer from his mission in Hawaii, a certain amount of interest centres around irrigation problems, especially in the north of the Island where periodic droughts are a source of serious loss to Planters.

The return of an officer of the Botanical Division from a mission at Coimbatore has rendered possible the inception of systematical experiments in regard to sugar-cane breeding. The Java cane variety P.O.J. 2878, has been received in Mauritius and, after a period of green house cultivation, is now being propagated in the field.

Tobacco.

Good progress is being made in the Tobacco Industry. 952 acres were registered from January to June, and nearly 103 tons of tobacco produced for the same period. Owing to this relatively large production, prices have been falling somewhat and air cured leaf at present sells at Rs. 1.20 to 1.10 per Kilo, while flue cured leaf is at Rs. 1.40 and sometimes less.

Fibres.

There was recently a drop in quotations for fibre, especially in the "Prime" grade, which now sells at Rs. 390 per ton. In view of previous quotations, manufacturers had striven to turn out a large proportion of their production in "Prime." Nevertheless, the trade is considered to be still satisfactory. The total export for the last six months was 1,051 tons.

No further progress has been made with regard to establishing a fruit canning and preserving industry, but a local fruit grower has set up a jam and syrup factory which is turning out quite creditable produce, generally meeting with favour.

There is an indication of revival in the local tea industry and Government has been approached with a view to financial help in this connection.

M. Koenig.

EMPIRE FORESTRY.

Results of the Third British Empire Conference.*

By R. C. Marshall,
Conservator of Forests, Trinidad and Tobago.

Introduction.

More than 60 delegates representative of many and various parts of the British Empire assembled in August, 1928, at Perth, Western Australia, on the occasion of the third British Empire Forestry Conference.

The total land area dealt with in the statements submitted by the forest authorities of the Empire was 8,587,000 square miles (the Empire covers about 11,000,000 square miles—one-fifth of the land area of the world) carrying a total forest area of 1,910,000 square miles. But of this forest area only about one-third is at present classified as merchantable and, so far, but 214,250 square miles have been definitely dedicated to timber production.

It is estimated that 3,600,000,000 cubic feet of timber are felled annually in the Empire—softwoods being slightly in excess of hardwoods.

Statements were submitted by 34 forest authorities from which it is evident that, since the previous Conference in 1923, the progress made has been generally substantial and in some cases remarkable. Consider for example the combined planting figures for Great Britain, South Africa and New Zealand—23,000 acres in 1923 against 89,000 acres in 1929: this refers to planting by government agency. New forest services have been established and the staffing of the colonial services has been improved.

Action on the Resolutions of the 1923 Conference.

1. Forest policy has received considerable attention but there is still much to be done.

2. As regards softwood resources the progress reported was most encouraging, as practically all parts of the Empire now seem alive to conserving and augmenting their resources.

3. Before increased trade in Empire forest products can be secured it is very clear that there are many difficulties not easily to be overcome.

4. The Imperial Forestry Institute was set up at Oxford in 1924 as a Central Institute for training and research.

5. The fifth resolution dealing with the activities of the British Empire Forestry Association has been carried out.

6. A Standing Committee on Empire Forestry has been established.

7. A well equipped forest products laboratory, which is doing useful work, has been set up at Princes Risborough.

8. Considerable progress has been made in Canada with regard to fire protection but unfortunately, comparatively little with silviculture. Losses from fires are still very great.

9. The last of the effective resolutions of the 1923 Conference dealt with shifting cultivation. It is clear that this is a very difficult subject and the problems connected with it have by no means been solved.

Discussions of the Conference.

Forest Policy.

The Conference re-affirmed Resolution No. 1 of the first British Empire Forestry Conference and stressed the need of laying down and adhering to a definite and permanent general policy. Other aspects of forest policy to which attention was drawn included, among others:—forest legislation for the protection of water supplies; for the prevention of erosion; for the control of shifting cultivation and for the better management of private forests: "provision should be made for the dedication and afforestation of areas near centres of consumption and to meet agricultural requirements. In this connection it may sometimes be necessary to make use of land fit for agriculture:" public education is required as to the importance of forests and forestry and instruction in the schools is suggested. This formed the subject matter of Resolution No. 1 of the Conference.

Australian Forestry.

A committee was appointed to report on this subject and their report was approved by the Conference as Resolution No. 2. "The necessity for dedicating, organising and managing the necessary area of state forests is forcing itself upon the attention of the various Governments with greater and greater insistence." This entails progress in the allocation of land and the acceptance of the principle of the sustained yield. "The neglect of the principle of the sustained yield, which is universally recognised as one of the cardinal maxims of forest management, has resulted in the rapid exploitation of the forest wealth of Australia."

As far as the area to be dedicated to timber production is concerned the Committee state the area should be determined irrespectively of those forest areas, often of poor quality, which are required for the local supply of firewood and those required primarily for protective purposes.

With the acceptance of the principle of the sustained yield working plans become a necessity and as continuity of forest work depends on continuity of funds "we recommend that each Government be asked to consider what measures can be taken to secure continuity of financial provision over a series of years, without which, the formation and execution of programmes of work is rendered difficult."

Special attention was also directed to silvicultural research and the importance of reserving areas for the production of firewood. The Australian forest departments are stated to be understaffed.

New Zealand Forestry.

Here again a Committee was appointed whose report was approved as Resolution No. 3.

* See also *Tropical Agriculture* Vol, V, No, 7, pp. 157-158.

"We would here take the opportunity of emphasizing the necessity for extending silvicultural research to the utmost extent possible." On such knowledge depends the possibility of the proper management on the basis of a sustained yield, of indigenous forests (including kauri pine *Agathis australis*, &c.) Appreciation was expressed of the afforestation work with exotic conifers particularly in the Rotorua district on rather poor pumice lands. The strength of the forest staff is considered inadequate.

Education.

In Resolution No. 4 the Conference approved the report of the Education Committee. The Conference considered that the decision to set up the Imperial Forestry Institute had been fully justified by results and recommended that steps be taken to put it on a permanent basis, fully equipped for its work.

The Committee state "we wish to say at the outset that real progress has never yet been achieved nor, in our opinion, ever will be achieved in countries where forestry, in the above sense (*i.e.*, policy, management, administration, &c.) is not regarded as a scientific profession, analogous, for example, with the profession of medicine.

It must carry with it a similar prestige and other attractions, such as will draw to its ranks men of the requisite calibre; and those men must be equipped with a scientific training designed to fit them for this work."

Forestry, as a profession, has suffered from a confusion of thought, in the lay mind which has tended (wrongly) to identify lumbering as forestry.

After setting out in general terms the essentials of the education which a forest officer should receive the Committee "feel obliged to express the opinion that all is not well with the pregraduate instructions of forest officers"—a view with which the writer (from experience gained on a Colonial Office selection board), quite agrees. They ascribe the main source of weakness to diffusion of effort among an unwarrantably large number of institutions.

The age at which candidates should be selected is briefly discussed and an expression of opinion recorded in favour of recruiting at the age at which they would normally enter a university, an appointment being guaranteed subject to completing their training satisfactorily. This method differs from that employed in recruiting agricultural officers—the writer confesses that he has a hankering for a good science degree followed by 2 years post-graduate training.

In this connection an interesting suggestion is made with regard to the Australian Forestry school at Canberra—"that the Australian Universities be approached forthwith with a view to granting a degree in his own university to any man who successfully completes the agreed 2 years course in science at his university, together with the forest course (2 years) at Canberra."

In New Zealand, despite the limited number of vacancies which become available annually, there are at present 2 forestry schools, neither of which is adequately staffed and the Committee recommend that 1 school should be abolished and the resources of both concentrated at 1 centre.

Forest technique.

Resolution No. 5 which deals with this subject is as follows: "The Conference approves the Report of its Committee on Forest Technique and desires to draw the attention of all Governments to the necessity of bringing their forest estates under organised management as soon as possible, with a view to ensuring a sustained yield of forest products, perpetuating timber and other industries dependent on forests and assisting agriculture.

Further, management being dependent upon a sound knowledge of the requirements of the species, emphasis is laid on the necessity for silvicultural research."

With the adoption of the policy of the sustained yield, forest working plans for the regulation of the yield become imperative. To regulate the yield it is necessary to know what stock is available for cutting and also to see that a steady supply of younger trees is coming along to replace those cut. This necessitates in turn, on the one hand survey and stock-taking and on the other a knowledge of the silvicultural requirements of the various species. Ultimately silviculture is the basis of all true forestry. The increasing importance of this subject is being realised but only the fringe of that knowledge necessary to success has been found. The field for research is almost unlimited.

Empire Forestry Bureau.

A bureau was first mooted in 1920 but in view of the various organisations which have since come into being the Conference was disinclined to set up another institute and referred the question to a special committee whose report was approved as Resolution No. 6.

The work requiring to be done, and the procedure by which it is recommended that it should be undertaken, are, in the main, as follows:—

(*a*) The preparation and publication for circulation to the forest departments of abstracts of current forestry literature and reviews by recognised experts: procedure:—to subsidise the Imperial Forestry Institute.

(*b*) The supplying of information as to investigations being carried out by research and other authorities; procedure:—publication of a résumé in the Empire Forestry Journal, annually or as necessary. The Director of the Imperial Institute also volunteered assistance.

(*c*) The provision of facilities for dealing with inquiries relating to:—

(i) silviculture and management ("the living tree"): procedure:—to subsidise the Imperial Forestry Institute.

(ii) timber : procedure :—the Forest Products Laboratory at Princes Risborough to handle enquiries from countries not possessing their own laboratories. If special study is involved funds to be provided by the unit of the Empire making the enquiry.

(iii) minor forest products : procedure :—refer to the Department of Scientific and Industrial Research, who, for the present, should pass on certain matters to the Imperial Institute.

(*d*) The according of assistance in the marketing of forest produce and the preparation of statistics bearing on the same : procedure :—the Committee recommend that the Empire Marketing Board be approached to set up an Empire Timber Office in the City of London.

Forest Products Research.

The most important matter, from the standpoint of the Colonies, that arose from discussions of the Committee appointed to consider this question was that the Forest Products Laboratory at Princes Risborough (which at present, is organised to serve the needs of the United Kingdom only) should extend its activities to serve the Empire, so that the testing of Empire timbers would become one of its normal functions.

The report of the Committee, which also dealt with the development of trade in forest products of the Empire, was adopted as Resolution No. 7.

Labour in relation to forestry.

The fact that forestry employs more labour than is ordinarily supposed, was forcibly demonstrated by the English and the Australian figures. Under English conditions forests may employ as much as one man to 28 acres. Organised forestry appears to offer opportunities for closer land settlement which should not be neglected—forestry can often employ more men per 100 acres than some methods of extensive agriculture.

Forests in relation to climate and erosion.

The Conference was of opinion that, whereas it was probable that the presence of forests had some influence on local climate, especially through the cooling of winds passing over forests, nevertheless sufficient evidence does not exist to prove anything definite. It was probable, however, that forests were likely to effect more in this direction in tropical than in temperate climates.

The damage caused by erosion in all parts of the Empire was forcibly demonstrated. The damage done consists in the erosion of hill sides, the silting up of rivers, the diminution in the perennial flow of streams, and the destruction of cultivated land by the deposition of sand and gravel both by the action of wind and water. It was shown that while losses from these causes during the last century had been immense, their magnitude, being gradually spread over a series of years, often escaped public attention. As a remedy, the preservation of the natural vegetation clothing the watersheds, was urged.

Living tree and the forest.

The Conference dealt in detail with the organisation of silvicultural research and agreed that such work should be conducted locally but co-ordinated at central institutes. Every forest department should have its own silvicultural research branch. The necessity for close co-operation with scientists in allied branches was expressed more especially in research in soil biology and the botany of forest trees.

With regard to staff employed on entomological and mycological research, officers should be given, as well, the general education of a forest officer, and should have experience in the executive branch of the forest department.

Finance.

Forestry is such a long-term investment that, if compound interest is charged, there are no comparable investments from which to determine the rate. Examples were given of indirect benefits which outweighed any financial consideration. No arguments were advanced for neglecting compound interest altogether, but there was a general consensus of opinion that the rate must be below the current rate of money. It was argued that natural wealth does not, in fact, increase over long periods of time at a compound interest rate approaching 5 per cent.

The duty of the State to produce timber, independently of financial results, was touched upon.

Pulp and Paper.

The increase in this industry in Canada has been very pronounced of recent years, and to-day the Dominion leads the world in newsprint production. This, in turn, is causing concern as to the supply of raw material.

Relief may be expected either in the near future, or as prices increase, from the utilisation of bamboo for the manufacture of paper pulp by chemical processes.

The principal economic difficulty in utilising Australian hardwoods is that it necessitates 70 per cent. sulphite to 30 per cent. ground pulp as against a reverse proportion with softwoods in Canada.

Timber supply and consumption.

Estimates, which are necessarily very rough, indicate that the world's supply of accessible coniferous timber is in the order of 1,000,000,000,000 cubic feet of which about one-sixth is in the Empire and one-half in North America.

The general discussion indicated that within the next decade or two, with the exhaustion of virgin supplies, and before our forests were placed on a sustained yield basis, a material reduction in the softwoods available for the market might be expected.

The hardwood (*i.e.*, non-coniferous) resources of the Empire were assessed at 200,000,000,000 cubic feet, and interest was shown in the possibility of utilising certain such species in lieu of coniferous timbers.

Fire Protection.

The Canadian situation shows considerable improvement since the last Conference, held in that country in 1923, particularly with reference to the more favourable public sentiment regarding the necessity of preventing forest fires.

Uncontrolled forest fires in Australia ravage large areas of valuable timber every year and constitute a distinct menace to the future prosperity of the Commonwealth and it was felt that the whole question needed more attention.

Exotics.

Previous to the Conference a questionnaire was sent to all parts of the Empire and at the Conference a Committee was appointed to study the available information. It reported that owing to lack of time and the incomplete nature of some of the material it was unable to do full justice to the subject, but recommended that the Imperial Forestry Institute, be requested to complete the enquiry.

The importance of exercising great care in the selection of seed was stressed, and the danger of the introduction of insect pests and fungoid diseases pointed out.

Caution is always needed with exotics and no species can be said to have finally established its position until it has passed through a complete rotation.

Ecology.

The discussion indicated that increasing attention is being given to this subject and that useful results are being obtained. The writer believes that insufficient attention has so far been directed towards this subject and that silviculture will benefit largely from an increasing study thereof.

Terms used in Forest Management.

A Committee was appointed to standardise and define certain technical terms used in Forest Management and their report was approved by the Conference as Resolution No. 9.

Trade names of Empire Timbers.

Before the Conference a tentative list was prepared by the Empire Forestry Association and a Committee which was appointed had this as a basis for discussion. As a result an initial list was compiled of about 200 species all fully identified botanically. The Committee recommended that this list be referred back to the Empire Forestry Association for check in consultation with Kew and for publication in due course.

The report of the Committee was adopted as Resolution No. 10 and the Conference trusts the list of trade names will be regarded as authoritative by all bodies interested in the utilisation of timber.

Next Conference.

Resolution No. 11. "This Conference accepts the cordial invitation of the Government of the Union of South Africa to hold the Fourth British Empire Conference in that Dominion in 1933 . . ."

The view was expressed that more time should be allowed for Committee work and for the detailed discussion of reports of Committees. It was essential that Governments should designate their delegates in ample time for them to prepare for the Conference.

Termination of the Conference.

The Conference ended at Auckland in New Zealand on the 22nd October when the Conference in a vote of thanks expressed its high appreciation of the arrangements made by the Governments of Australia and New Zealand both for the conduct of its work and for the hospitality extended to delegates.

Summary.

After comparing the summary reports of the 1923 and 1928 Conferences the outstanding impression is the increased emphasis laid on the principle of the sustained yield and all that it implies, particularly, at present, silvicultural research. It may be doubted if even 1 per cent. of the forests of the Empire are being managed so that timber shall be available year after year. Cutting timber brings in money; bringing on young trees for the future whether by natural or artificial means costs money.

Many parts of Europe have been managing their forests on the basis of a sustained yield for the last two or three hundred years, so that it cannot be considered over premature to call on the Governments of the Empire to set about putting their (forest) house in order and so, to treat their forests as a crop to be kept perennially productive and not as a mine to be worked out and abandoned.

It may be noted in conclusion that, excluding the prescribed Statements, the various papers prepared for the Conference form, when bound, a book of just over 900 pages. These papers, of course, formed the ground work for the discussions of the Conference—the main trend of which has been indicated in these notes.

GUMMOSIS IN BARBADOS.

Cases of the bacterial disease of sugar-cane generally known as "Gummosis" have recently been recorded and identified by Dr. Briton-Jones in Barbados. Two important local cane varieties in particular are affected, namely Ba. 11569 and 6032. The latter variety fortunately is not grown to any great extent and therefore could easily be replaced. Ba. 11569 is, however, commonly grown since it has certain very desirable characteristics. Dr. Briton-Jones has suggested that the losses due to the disease in question might be ascertained by comparing the statistics available for clean and diseased crops of Ba. 11569 with those of the resistant variety B.H. 10/12. It is not anticipated, however, that the disease will so far have caused any appreciable loss and the Barbados Department of Agriculture, fully alive to the situation, have the matter well in hand.

SUGAR CONFERENCE.

I. Field Information.

[*Published below are summaries of the more important papers, dealing with Sugar-Cane Cultivation, that were read at the Third Conference, held at Sourabaya, Java, of the International Society of Sugar-Cane Technologists.*]

Biological control of *Oregma lanigera* **in Java.** DR. E. H. HAZELHOFF. *Bulletin No.* 1.

THE woolly cane louse is the most important aphid pest of sugar-cane in Java. This insect is parasitized by the native Chalcid, *Encarsia flavoscutellum*, Zehntner. Observations indicate that when this parasite is present in the sugar-cane fields early in the season, the aphid is held completely in check and that under the usual conditions, the pest reaches its maximum of numbers in November and December, and this maximum is followed by a rapid decrease, which is due to the action of the parasite.

The increase of the parasite is assisted by (*a*) discarding all insecticidal control of colonies of Oregma (or parts of colonies) where the parasite was abundant and (*b*) transferring Encarsia to colonies where it did not appear of its own account. If 40 per cent. of the aphids in a colony are parasitized, then the colony is left undisturbed. If 20 to 40 per cent. are parasitized, then the lice on the newly affected leaves are exterminated as completely as possible, and if the degree of parasitism is less than 20 per cent., control by insecticides is made as complete as possible and the parasite is introduced into the colony in order to prevent a renewed outbreak of the pest. Trials have been made with establishing parasitized colonies of the lice in the cane fields before the pest had become established. These methods have given promising results and further tests will be made in the coming season.

H. A. B.

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Determining the Damage done to Sugar-Cane in Java by the White Top-Borer and the Striped Stalk-Borer. DR. E. H. HAZELHOFF. *Bulletin No.* 2.

THE white top-borer (*Scirpophaga auriflua* Zell. var. *intacta* Sn.) is a small Pyralid moth, the larva of which kills the vegetative cone of both old and young sugar-cane plants. This results in the death of the young plant (shoot): in the older stalks the killing of the growing point often results in the development of one or more sprouts from lateral buds. The loss of a few shoots in the fields of young canes up to an age of 3 to 4 months does not do much harm since the loss is often, if not usually compensated for by the more vigorous growth of the remaining shoots from the stool, even when the cane is as much as 6 to 8 months of age. Extensive experiments in all parts of Java in which untreated plots (controls) were compared with plots in which from 5 to 10 per cent., and even as high as 20 per cent., of the stalks were cut away. The compensation amounted to 58, 52, and 43 per cent. respectively in plots in which 5, 10 and 20 per cent., of the stalks had been removed. The longer the interval between the cutting out of the stalks and the time of harvesting the better the compensation. Compensation is calculated in terms of the damage to be expected if no compensation took place. The conclusion arrived at from these trials is that the estimation of the damage caused by the white top-borer is a very complicated affair. The possibility of compensation must not be left out of account when calculating the damage caused by attacks of this insect pest.

The striped stalk-borer (*Diatraea venosata striatalis*) is another Pyralid moth whose larva bores into the stalks of both old and young sugar-canes.

When very young shoots are attacked they may be killed by the borer as in top-borer attacks. Older internodes are bored into and loss of sucrose content and weight is the result. It was found that damaged joints showed a loss of 26 per cent. $\pm$2 per cent. of available sucrose, and that an average 10.9 per cent. of all joints were damaged and it was calculated that the total damage amounted to a loss of 2.83 per cent. of the whole crop. This is considered a very conservative estimate since no account was taken of dead and dying stalks which were left in the fields at harvesting. Moreover it is not considered that compensation of damage to older joints is of much importance since the joints above the damaged ones will suffer rather than benefit by the presence of such damaged joints.

H. A. B.

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Mechanical Control of the White Top-Borer of Sugar-Cane in Java. DR. E. H. HAZELHOFF. *Bulletin No.* 3.

THIS bulletin refers to the trials made on several large estates in Java in attempts to control the top-borer (*Scirpophaga auriflua* Zell. var. *intacta* Sn.) by cutting out at regular intervals all shoots showing injury resulting from top-borer attack. The conclusion is reached "that short-lasting but exceedingly intensive control (from about 3 months to about 6 or 7 months' age of the cane) will yield the best results."

H. A. B.

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Miller and Grower in Northern India. NOEL DEERR. *Bulletin No.* 7.

THE author reviews briefly the conditions under which the sugar industry has developed in Northern India, where three systems of land tenure are at present extant. Sugar-cane cultivation and manufacture in India have been confined for 2,500 years to an area of some 100,000 square miles, in the provinces of Bihar

and Orissa and the United Provinces of Agra and Oudh. It is in this area that 21 out of 26 of India's sugar factories are situated. Supplies of cane are obtained by these factories as follows: The factories may (1) act as landowners and produce their own cane (*Zeerat* cane) or let their land to tenants who supply what is known as estates' *ryaiti* cane, (2) enter into agreements with Europeans and Indians to plant a certain acreage yearly and purchase cane so planted, (3) buy cane (*kushki*) in the open market where it is often secured by the payment of advances both at planting or after the crop has been established, (4) combine all the above methods. Most factories depend on *kushki* supplies. Of the total cane milled in the factories this year (about 900,000 tons) 80 per cent. will be grown by peasant cultivators and the balance by European planters. The tendency in India is therefore to divorce the cultivation of cane from the factory. There can thus be little co-operation between the grower and the miller as most of the sugar is purchased from illiterate peasant proprietors. Co-operation has, in fact, given way to a system of education by which the growers are instructed in the uses of superior varieties of cane. In addition, free seed is distributed and demonstration plots have been established in selected areas while payments of premiums are made on approved varieties.

The price of cane is governed broadly by the selling price of sugar but is complicated by the presence of a market for cane in gur. One advantage enjoyed by the growers is that they often get their crops cut free, the leaves and tops forming the wages to the labour, who use them as cattle fodder.

"The difficulties," says the author, "that exist with regard to the sugar industry in India do not lie in the lack of raw material but rather in the widely scattered areas over which cane is grown, in the multiplicity of small holdings, in the expense of collection and in the absence of concentrated intensive cultivation which is the rule in other cane growing localities. The problem is social rather than agricultural." Northern India is essentially a country of self-supporting and self-contained village communities where the production of crops marketable outside the community is a secondary consideration. "The natural remedies are easy to formulate but difficult of execution, and the difficulties are accentuated by the intense conversatism of the great bulk of the population whose customs and prejudices are protected by the Imperial Government." In the meantime, however, organised research and the organisation of supplies have already received attention and it is hoped that eventually a stable and prosperous industry may be established by taking advantage of the lessons that may be learnt from other countries.

G. G.

Summary of investigations of the Soil Fauna of Sugar-Cane Fields in Hawaii. R. H. Van Zwaluwenburg. *Bulletin No.* 8.

This summary is introduced as follows:—

> "The study of the soil fauna of Hawaii sugar-cane fields has fallen under 2 heads. One includes all animal life of a size between the truly microscopic, and the larger forms such as root-grubs, to which is given for convenience the name 'macrofauna.' The second has to do with the spear-bearing species of nematodes which attack the roots of the cane plant."

Macrofauna.—Field studies were confined to the upper 9 inches of soil, with the object of determining species attacking the roots of sugar-cane.

The macrofauna averaged about 72 million per acre or over 1,600 per surface square foot. More than 58 per cent. of this number were found potentially injurious. In fallowed fields containing humus material from previous cane crops the same soil inhabitants were found, but only to the number of 58 million or 1,300 per surface square foot.

Isotomodes.—Minute collembolous insects, comprised 48 per cent. of the total macrofauna averaging 750 per surface square foot. These insects make round, comparatively deep, pits in the cortex of the root, which seldom or never extend into the stele. They appear to prefer decaying organic matter. In soils deficient in humus they may cause serious reduction of secondary root-growth.

Mecistocephalus, spp.—Two species of small centipedes are common in the soil. They make pits in the roots. Their injury to cane roots is negligible and possibly their pitting of the roots is for the purpose of obtaining moisture rather than food.

Unidentified millipedes are normally scavengers, and although they cause pitting of the roots under laboratory conditions, they probably are not pests of the sugar-cane in the field.

A small thysanurid insect (*Japyx* sp.) and small snails feed on cane roots to some extent.

The conclusion arrived at is that the macrofauna is of distinctly minor importance in Hawaiian cane soils.

Nematodes.—Two species of spear-bearing nematodes are everywhere present in cane roots in Hawaii. They are *Tylenchus similis* which is, also, known from Fiji and Jamaica (bananas) and *Heterodera radicicola*, the cosmopolitan root-knot nematode. Tylenchus occurred in 50 per cent. of all the cane stools examined and Heteroda in less than 40 per cent., while 25 per cent. contained neither of them. The Tylenchus nematode was the most important both from its abundance and from its effect on the cane roots. It lives mostly in the cortex of the root causing longitudinal lesions, which, at first reddish, become purplish and eventually black. The death of the root often results from these attacks. Other hosts

are banana, edible canna (*Canna edulis*), pineapple (rarely), pigeon-pea (*Cajanus indicus*) and the corms of nut grass (*Cyperus rotundus*). Tylenchus is more abundant at the lower levels :—above an altitude of 2,000 feet it practically disappears.

The maximum infestation occurs in canes at the age of from 12 to 16 months. There is a difference in infestation in certain varieties. Taking as 100 the infestation of H 109 of all ages, that of yellow Caledonia is 173, of D 1135 is 73, of Yellow Tip is 38. The first 2 of these varieties occupy lands of about the same level so the figures relating to them are comparable, but D 1135 and Yellow Tip are generally grown on the higher lands so that elevation and possibly temperature and rainfall must be considered in connection with these 2 varieties. Saline soils high in dispersed colloidal material are comparatively free from Tylenchus. This condition is true of certain land formerly in rice recently brought under cane cultivation. A similar condition occurs in Java where soils formerly containing this nematode in seriously injurious numbers when cane was grown to the second ratoon, were found to be comparatively free after a system of single cropping was adopted in a rotation with rice.

The root-knot nematode (*Heterodera radicicola*) is believed to be of less importance as a sugar-cane pest than Tylenchus because its attacks do not cause a breakdown of the roots.

Control.—Many Tylenchus individually die in the rotting roots, and they are preyed upon by a predacious nematode (*Mononchus*) while Heteroda is attacked by a fungus (*Microcera* sp.). It is suggested that possibly minor alterations in field management might so improve the moisture-holding capacities of the soil as to make it more favourable for the environment of Mononchus and Microcera. Soil fumigants and crop rotations are not practical under Hawaiian conditions even if they were effective. Stimulation of root growth by the applications of mudpress or molasses as a fertilizer is apparently useful, by causing root development enabling the plant to support numbers of the nematodes without suffering serious ill-effects from their attacks.

H. A. B.

* * *

Comparative study of yields obtained from cane cultivation in Hawaii, Java and Mauritius.

J. D. de Speville. *Bulletin No.* 13.

This bulletin was written with the object of finding some basis of comparison between the sugar yields of Hawaii, Java and Mauritius. A brief survey is given of the geographical and climatic factors of the three countries concerned and of their respective methods of sugar production. In Hawaii the sugar industry is in the hands of powerful companies which practice intensive methods of cultivation. Over half of the cultivated area is irrigated, but of this half only 50 per cent. is harvested yearly. In Java, cane is grown every year, in rotation with rice, on irrigated soils which are mainly composed of volcanic deposits brought down by the rivers. There are no ratoons. Emphasis is laid on the fact that as the cane matures between 11 and 14 months, 100 per cent. of the area cultivated, is harvested every year. In Mauritius the land is not irrigated and of the total area cultivated about $\frac{2}{3}$ belong to small proprietors practising an extensive system of cultivation and to estates without factories, whereas the remaining $\frac{1}{3}$ which amounts to 50,120 arpents, belongs *as in Hawaii*, to proprietors who use intensive methods of cultivation. Conservation of humus and mineral elements is aimed at, the trash being left in the field and the ashes of the bagasse, the molasses and the refuse of filter presses being returned to the soil. Both farmyard manure and artificials are used. The average rainfall is 200 inches in Hawaii; 79 inches, with extremes of 16 to 125 inches in Mauritius; and 40 to 119 inches in Java.

Turning to yields, Mauritius and Hawaii are dealt with first. Working on the figures obtained from the area of 50,120 arpents cultivated intensively in Mauritius by estate owners and, of which 83.6 per cent. is harvested every year the production of an area of 2,000 cultivated arpents is worked out as follows in both countries :

	Area cultivated arpents.	*Total yield sucrose Kg.*	*Yield of sucrose per arpent. Kg.*
Hawaii ..	1,000 (50 per cent.)	3,740,000	3,740
Mauritius ..	1,672 (83.6 per cent.)	3,762,000	2,250

The figures obtained in Mauritius thus compare favourably with those of Hawaii.

In Java the 10-year average yield of cane per arpent works out at 43.5 metric tons as against Mauritius' 10-year average of 29.5 metric tons. The vegetation period for Mauritius, however, is 18 to 24 months and in this connection Java scores a very great natural advantage (a temperature factor) as its cane ripens in nearly half the time it does in Mauritius. Also, both in Mauritius and Hawaii the cane crop has to undergo 2 dry periods before it is harvested. Mauritius soils are, on the other hand, not irrigated and the author is of the opinion that if they were, the average yield of the present virgin or plant cane would be increased by 25 per cent., and by another 4 per cent. if damage by cyclones were considered. Experiments carried out in Mauritius on irrigation have demonstrated that this practice might be profitably introduced as the average rainfall is, on the whole, higher than in Java which is also irrigated.

G. G.

Short Remarks on the Cytology of Saccharum. Dr. G. Bremer. *Bulletin No.* 15.

Dr. Bremer is the world's leading authority on sugar-cane cytology, and he gives a succinct and extremely valuable account of the chromosome numbers of some of the more recent Java seedlings.

The details will be of interest only to specialists, who will want to read the whole bulletin, but the broad outline of Dr. Bremer's results may be given here. He has shown that when a "noble" cane, of the species *Saccharum officinarum* is crossed with the wild *S. spontaneum*, the chromosome contribution of the "noble" parent is in some way doubled. When the hybrid is crossed back again to the "noble" cane (the "second nobilisation") the contribution from the latter doubles again. Seedling canes of the second nobilisation therefore have high chromosome numbers (about 148) as compared with *S. officinarum* (80).

At the third or fourth nobilisations, no further doubling takes place, and the numbers therefore become smaller again (*e.g.*, 2878 P.O.J. has 119 or 120), but by crossing *S. spontaneum* in again at this stage, numbers as high as 170 have been obtained.

The practical interest of the matter is that it is thought possible to obtain sugar-cane types of high value with very high chromosome numbers, and this year many crossings have been made for that purpose.

It is, of course, not correct to suppose that the value of a cane variety is proportional to its chromosome number, but our knowledge of polyploid series in other genera indicates that there may well be hope in the new method of breeding. As Dr. Bremer says, "We do not yet know whether this way of cane crossing may yield any results, but it is surely worth while to try it." This is, in any event, an interesting case of cytology not only explaining genetic phenomena, but even beginning to influence a practical breeding programme. The work has considerable bearing on questions quite unconnected with sugar-cane, as for example certain problems in the breeding of bananas.

E. E. C.

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General Remarks on Cane Cultivation and Field-Operations in Java. Dr. V. J Koningsberger. *Bulletin No.* 17.

In the course of a few pages, and with the help of a couple of diagrams, a very clear and up-to-date account is given of the general conditions under which cane is grown in Java, and of the wonderful improvement brought about by the introduction into general cultivation of the cane P.O.J. 2878.

Certainly, apart from a plentiful supply of cheap labour, the Java sugar industry appears to possess few natural advantages. The soils, mostly of tertiary and later formations, are not distinguished for great fertility, though some of the recent volcanic soils are described as being very fertile. Mention is made of the "Lahars," or mudstreams which in comparatively recent times have brought down large quantities of material from the volcanoes.

It appears, however, that estates suffer most in respect of the conditions on which they hold their land, as when it has been used for a single crop of cane it must revert to the native owners. This results in a 3-year rotation of sugar-cane with swamp rice and other crops, and implies that all cane is necessarily plant cane. Ratooning is unknown, and as the cane crop follows swamp rice, considerable expense has to be met in draining and aerating the land to make it capable of growing heavy crops of cane.

It is in consequence of these conditions that the cultivation of cane in Java is of a very intensive character. With the exception of a few districts where the soils are light, all fields are operated on the *Reynoso* system, which implies deep trenching by hand, and although many attempts have been made to substitute more modern mechanical methods, manual labour is still cheaper and more reliable. Manures are used to a surprising extent, 4 cwt. an acre of sulphate of ammonia being quite a common dressing, applied carefully in 2 or 3 doses by hand to each stool, and on the poorer lands supplemented by phosphates.

As is known, a crisis arose in the sugar industry of Java in 1883 owing to the ravages of the dreaded "Sereh" disease, but, as Dr. Koningsberger puts it, to this disease may be ascribed the foundation of Sugar-Cane Experimental Stations in Java some 40 years ago. They set themselves the problem of discovering the cause of the disease, and the task of raising new canes which might be immune. In the meantime it was incidentally discovered that by using as planting material, canes grown in the mountain regions, the disease could be kept at bay, and a very large organisation sprang up to supply such canes—a safe but expensive precaution.

It is only in recent years that the efforts of the plant breeders have been crowned with success, with the introduction of the now famous P.O.J. 2878. Forty years ago "Zwart Cheribon" occupied nearly the whole area and was reckoned to produce 2.8 tons of sugar an acre; this was gradually replaced by other varieties which improved the yield up to 4 tons; the new cane P.O.J. 2878, though only appearing in cultivation in 1922, occupied this year, 93 per cent. of the total cane area.

A short account of the diseases and pests from which sugar-cane suffers in Java closes this bulletin.

R. C. W.

Field Experiments for Sugar-Cane in Java and the results obtained, *Fil. Lic.* G. BOOBERG, Pasuruan. *Bulletin* No. 21.

THIS bulletin, which gives an account of the Javanese sugar-cane experiment service, covering the period from 1905 to 1928, presents a record of work done which agriculturists in British Colonies may well envy. Since 1912 the number of experiments carried out annually has increased rapidly and now stands at the high figure of 2,385. This amounts to one experiment for every 80 hectares (=200 acres) under cane. The experiments are carried out by the factories, and the percentage of factories taking experiments has increased from 40 per cent. in 1906 to 84 per cent. in 1928.

Although the total number of experiments is so great, the bulletin states that by far the greater number meet the high standard of requirements set by the Experiment Station. From 10 to 20 plots of each treatment or variety, distributed chessboard wise, are used, and *each plot is harvested and milled separately*. Thus the results are obtained in the most useful form, as yield of sugar per hectare. From the examples given, the area required for 1 experiment would be from 1 to 3 acres, which means that about 1 per cent. of the total cane area is devoted to experimental work. The labour in field and factory expended on the experiments must be an even greater fraction of the total. That the factories should be willing to undertake this expenditure of time and money is an eloquent tribute to the experiment service and to the value of the results obtained.

The type of experiments carried out has varied in an interesting way. From 1912 to 1916 variety trials formed only a small percentage of the total, the experiments being concerned mostly with cultural methods, and the effects of phosphates, nitrogen, molasses and stable manure. Since then the variety trials have increased steadily in number, while the manurial experiments have become mainly experiments on quantity (optimum dose) of sulphate of ammonia. At the present time (average of 1927-1928) the distribution is roughly as follows: Experiments on varieties 39 per cent., on cultural methods, &c. 18 per cent., on optimum sulphate of ammonia 33 per cent., and on other manurial problems 10 per cent. Special importance is attached to the question of optimum sulphate of ammonia, and it is intended to devote 50 per cent. of the plot experiments to this problem.

In certain respects the methods of field experiment described in the bulletin differ from those now coming into use in British Colonies. The principle of *random* shuffling of the order of the varieties in each unit of the experiment is apparently not, as yet, adopted, but the order is deliberately varied, so that a balanced arrangement results. The result is an arrangement which is certainly as difficult to lay out as one arrived at by random shuffling; and the fact that such arrangements can be set out successfully, on so large a scale, under estate conditions, should dispose of the argument that, in order to prevent mistakes in lay out, a regular repetition of varieties in the same order is to be preferred. The most important difference in method, however, is the severe limitation placed in the Java scheme on the scope of the individual experiment. "Only 1 problem should be examined in each experiment, by preference with few (2 or 3) experiment objects." The large total number of experiments carried out in Java is no doubt connected with, and in part compensates for, this limitation in the scope of the individual experiment. The problem then arises of establishing more general conclusions from the results of a number of experiments, and it would be very interesting, in view of the wealth of data accumulated each year in Java, to know what methods of analysing the data are used. As a result of the work of Fisher and others at Rothamsted, the alternative method, of examining a small number of important problems in each experiment, is likely to find more favour in the British Colonies, and is, moreover, easily adapted to precise analysis. If with these methods we can combine the thoroughness and enthusiasm shewn by the planters and experiment station staff in Java, we may hope along somewhat different lines to rival their fine achievement.

E. J. M.

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Manuring Sugar-Cane in Java. *Fil. Lic.* G. Booberg, *Bulletin* No. 22.

MR. G. BOOBERG summarises the results of several years' experience with some 60 different fertilising materials that have been examined in field experiments. Most of these, he said, have failed to obtain a foothold.

There are only 2 plant nutrients of paramount importance in Java: nitrogen (on all soils) and phosphoric acid (not on young volcanic soils). By far the principal source of nitrogen used in Java is ammonium sulphate; Chile saltpetre (sodium nitrate) and urea cannot compete with ammonium sulphate on account of their greater hygroscopicity in the Tropics. The phosphate fertiliser used is chiefly double superphosphate. Stable manure is a good improver of light soils which are deficient in water; a total substitution of ammonium sulphate by stable manure is always detrimental. Compared with ammonium sulphate, double superphosphate, and stable manure, the quantities of other fertilisers used in Java are relatively very insignificant. Molasses diluted with an equal amount of water and applied in the furrows before planting has proved of some value on sandy soils—especially on gravelly soils—and on soils with a hard subsoil. Press cake, which contains about 1½ per cent. of P_2O_5, with considerable amounts of organic matter and lime, has some effect either as a soil improver or as a phosphatic fertiliser; as it chiefly influences cane growth, use of this material is often not of pecuniary advantage, though defecation press cake a year old has mostly a favourable effect on very

light, as well as on very heavy soils. On account of its high lime content, carbonation press cake often has injurious after-effects. Flue ash, which contains 1½ to 2½ per cent. of P_2O_5 and about as much potash, has a favourable effect on rather heavy soils deficient in phosphate, due possibly to its effect in improving the structure of such soils; on lighter soils its effect is relatively smaller. Green manuring has proved of benefit only in exceptional cases, as in the Djokja district. The exact amount of any fertilising material cannot be defined in any case without the aid of well-executed field experiments.

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Tilling for Cane Planting in Java. Ir. J. VAN DYK. *Bullletin No.* 23.

THIS bulletin again emphasises the conditions in Java which make it necessary to adopt an intensive system of cultivation in order to get as much as possible out of the land during the short term for which the companies occupy it. In spite of attempts at introducing modern methods of mechanical tillage, the *Reynoso* system, which owes its name to one Alvaro Reynoso of Cuba, who wrote a treatise on the system in the sixties, and gave the first impulse to its introduction into Java, is still found the most profitable. The essential point of this system is that the land is deeply trenched by hand labour, the earth from each trench being heaped on the intervening area which is left untilled. This enables the cane as it is gradually earthed up, to develop roots at each internode, and thus a plant is produced which is well supported, and supplied with a deep and spreading root system.

On taking over the land from the rice grower, and after the necessary drains have been dug, trenches are laid out, generally running north and south, so that the sun can penetrate into every row, and varying in size according to the nature of the land. These trenches will generally be 15 to 23 inches in width and the intervening strips 19 to 37 inches across: the depth 11 up to as much as 17 inches. Where the shallower trenching is practised, the bottom of the trench may be deeply dug to loosen the soil.

There are various modifications in this *Reynoso* system which are briefly described. Sometimes the loosened soil at the bottom of the trench is pulled to the side, so that the cane sett is planted on the untilled surface: another modification is to replace, before planting, part of the soil removed from the trenches, after it has been exposed to the air for some time.

A description of the use of the plough occupies the next section, and it is interesting to learn that before the introduction of the *Reynoso* system, tillage with the Javanese plough was the general practice. There was at one time a temporary reaction in favour of the plough, but to-day, ploughing is much less practised than hand trenching. The plough used is mostly the simple Javanese plough; the author of the bulletin has interested himself in mechanical cultivation, and has demonstrated the use of cable drawn ploughs, but it is stated that there is no great chance of an extension in the use of such methods of mechanical tillage.

The third section of the bulletin deals with tillage operations after planting. The earth from the trenches that lies upon the intervening undug strips is gradually, generally in 3, but sometimes in 4 operations, moved towards the young plants, until the trenches are completely filled. Whether these bare strips should be cultivated appears to be an open question, as some growers prefer to leave them undisturbed on account of the damage that may be done to the root system of the canes. In any case, in the final hilling, which is universally adopted, these strips are thoroughly dug, and the earth laid closely against and between the cane stalks. This operation stimulates the production of fresh roots and at the same time provides drainage to the growing crop.

R. C. W.

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Planting and Plant Material. Ir. J. VAN DYK. *Bulletin No.* 24.

THE first two portions of this bulletin deal with the methods of planting and with the nature of the planting material hitherto used: the third portion is the most interesting as it describes the changes in the supply of planting material which have been brought about by the introduction of P.O.J. 2878.

Planting is done by placing the setts in the bottom of trenches either in a shallow layer of partly dried and oxidised soil which has been raked down from the intervening ridges, or else, but less commonly, in the untilled soil. Precautions are taken to avoid as much as possible the puddling of the soil by the trampling of the labourers and with this end in view, planting in holes is sometimes done: water is only applied to these holes and the labourers stand on the dry intermediate ridges. The distance between the cuttings or "rajoengan,"—the word used to describe a part of the stalk of the cane with sprouted buds,—varies considerably; 12 to 30 in 10 yards covers general practice. The setts are placed with the buds at the side, so that all eyes have an equal chance of germinating, and generally flat, though sometimes they are planted obliquely to guard against the vagaries of the weather.

Planting material is generally known by the native name of "bibit," there are two kinds, "bergbibit" the crop specially grown in the hills for this purpose, as a protection against *Sereh*, and "vlaktebibit" or material from crops grown in the plains.

The supply of all seed cane is from a "grandmother field" on the highest level, through a "mother field" on a lower level and finally from an export field, whence the cane is carried to the main crops on the plains. The use of "vlaktebibit" has been largely abandoned for some time

in favour of such "bergbibit" owing to the prevalence of *Sereh*: in planting this, either ordinary setts from the top or body of the cane were used, or else the "rajoengan" mentioned above, which is cane which has been topped in the field, and on which the buds have started to sprout. Whatever the material used for planting, disinfection is commonly practised, both on the setts and also on the cutting knives: for the former Bordeaux mixture (containing 2 per cent. sulphate of copper and 2 per cent. unslaked lime) and coal tar are used, for the latter, lysol. The diseases mainly feared are the pineapple disease (*Thielaviopsis ethaceticus Went*), red rot (*Sclerotium* spp.), and leaf scald.

The arrival of P.O.J. 2878 has made great changes in the production and supply of "bergbibit," and theoretically it should be possible to plant tops entirely from the fields which are being harvested. Actually it has been found that this cane must be planted early in order to obtain the maximum yield, and so arrangements are being made for the supply of "bibit" earlier than the milling season. "Vlaktebibit" fields are topped rather low; the large quantity of tops thus obtained are planted at once or kept in nurseries if land is not immediately ready, while the "rajoengan" thus produced is the main planting material used. Two-budded setts are found to be the best.

R. C. W.

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Plot Arrangement and some Results of Variety Tests in Louisiana. GEORGE ARCENEAUX, *Bulletin No.* 31.

FOR variety test work in Louisiana long plots, 3 cane-rows wide, are used. The experimental area is divided into a number of units, or blocks, corresponding to the number of replications, and in each unit the varieties are arranged side by side, each variety being represented by 1 plot only. This grouping eliminates, from the comparison of varieties, errors due to major soil differences between different blocks of land.

Comparison of varieties in long narrow plots, side by side, introduces, however, another possible source of error, namely "border effect," and it is with this problem that the bulletin under review is mainly concerned. For the purpose of minimizing this border effect, the order of the varieties in the units of the experiment is varied, so that each variety shall appear next to every other one practically the same number of times. It is doubtful, however, whether, even from the point of view of border effect alone, the variation of order actually introduced is sufficiently thorough. Thus, in the example given in the bulletin, in which 12 replications are used and 6 varieties compared, only 3 different orders of the varieties are used, viz.: A, B, C, D, E, F; E, C, F, A, D, B; and C, A, E, B, F, D; each of these orders being repeated 4 times. Apparently it is not realised that a random arrangement, whereby the order is completely reshuffled in each unit, is not only essential if the test is to be statistically sound, but is at the same time the fairest way of averaging the border effect between the varieties to be compared.

The rest of the bulletin is devoted to analysing some data obtained on border effect in certain variety tests. Making separate weighings of the middle and the outside rows, it was found that the yield variation of the outside rows was very much greater than that of the middle rows, the mean coefficients of variability being 11.0 and 5.1 respectively. This marked difference in behaviour between outside and middle rows suggests severe border competition; but the author concludes from further studies that competition plays only a minor part. He finds that there is no significant association between yielding capacity of a variety and the deviations from the mean yields shewn by adjacent plots. There is a slight tendency for low plots to be adjacent to high yielding varieties and conversely, but this correlation would account for less than 1 per cent of the observed variation in plot weights. Similarly, there appears to be no connection between the yielding capacity of a variety and the superiority or inferiority of its outside rows. The author concludes that soil heterogeneity and differences in stand are more important sources of variation in plot yields than is border effect.

In view of the fact that reduction of error due to soil heterogeneity is apparently the principal reason for the use of the long narrow plot in Louisiana, this conclusion is somewhat unexpected, and it suggests a re-examination of the assumptions underlying the use of plots of that width.

E. J. M.

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Report of the Committee on Quarantine Practice in Relation to Inter-regional Movement of Sugar-Cane Propagating Material. E. W. BRANDES. *Bulletin No.* 32.

THE risk of importing new pests and diseases by the introduction of exotic varieties of plants and plant products has recently attracted much attention. With regard to the importation of new cane varieties, the above Committee recommends that strict quarantine services should be established in all cane-growing countries. Details of the procedure which should be adopted are expressed, together with an estimate of the resulting initial and annual expenditure.

A. K. B.

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Fungi Associated with Root Rots of Sugar-Cane in the Southern United States. R. D. RANDS. *Bulletin No.* 33.

IN this paper Rands summarises the investigations which are being carried out by the United States Department of Agriculture on the various root diseases of cane which are thought to be largely responsible for the degeneration of certain

cane varieties. In Louisiana there is a striking contrast between the newly introduced vigorous Java varieties P.O.J. 36, 213 and 234, and canes previously introduced such as D. 74 and Purple varieties. An extensive examination of recently rotted roots has been undertaken, in order to identify the organisms which are associated with the disease. Numerous fungi including 11 different species of the genus Pythium have been determined, together with certain species of nematodes, molluscs and centipedes. Only 1 species of *Pythium* has shown an aggressive parasitic tendency in inoculation experiments conducted in steamed soil. This species, which possesses great variability, and possibly biological forms, appears to be identical with *Pythium arrhenomanes*, which is the cause of a root rot of maize in Wisconsin. The remaining 10 species are tentatively classified as weakly parasitic or wound-infecting types which are dependent on the cane having been previously damaged by soil fauna.

A. K. B.

A NEW JAVA CANE.

During the coming months of December and January the Java Sugar Experiment Station will begin the distribution of seed cane of the new variety P.O.J. 2961 for plantation field tests to determine its value relative to P.O.J. 2878, which is now the dominant variety in that island. The new variety is described as follows:—

P.O.J. 2961 was originated in 1926 (P-seedling): the mother is P.O.J. 2878 (2364 P.O.J. x E.K. 28); the father is 2940 P.O.J. (272 P.O.J. x E.K. 28); it is thus a crossing of the 3rd and 4th nobilitations. It is a long, green, strongly growing cane, which is yellowish green to yellow when ripe; the internodes are cylindrical to mildly—but sometimes very markedly—barrel-shaped. Flowering is scant and late, and stooling is good; the stalks are erect and of good thickness; the leaves are bright green with overhanging lips. It is easily propagated by suckering; germination is good; during the first months the growth is rather like that of P.O.J. 2878 but less rapid than P.O.J. 2952. In general this new variety shows much similarity to P.O.J. 2878; it differs in having relatively shorter internodes, which are also in some cases distinctly barrel-shaped; the young shoots are more erect than those of P.O.J. 2878 and nearly always have flatter leaves. Tests so far made with this variety have not indicated that it has any special adaptibility to particular kinds of soils, and it may therefore be tested alongside of P.O.J. 2878 on both light and heavy soils.—(*Facts About Sugar*, Vol. XXIV, No. 40.)

The Editor requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

WITCH-BROOM IN SURINAME.

By C. W. Wardlaw.

[*The following brief account of Witch-broom disease of Cacao was collected during the writer's recent visit to Suriname. With acknowledgments to Prof. G. Stahel.*]

In 1895 the cacao industry of Suriname was one of very considerable importance as measured by the production of 87,530 cwts. for the year. About that time a disease—witch-broom—causing considerable damage was reported in the Saramacca district. By degrees it spread throughout this area and began to be noticed on the lower reaches of the Commewijne and Suriname rivers. The effects of the disease were seriously felt in 1902 while by 1904 the damage done was so great that planters were faced with ruin. In 1905 and 1906 estates lying on the upper reaches of these rivers were also seriously affected. The following table gives some idea of he extent of crop reduction.

Table I.

Average Crops. Years.	5 *Years periods. Cwts.*
1893-1897	68,660.
1898-1902	59,500.
1903-1907	30,650.

By 1905 the situation had become so acute that planters began to look for an alternative crop. As a result, the banana industry was inaugurated in 1906, and many of the badly affected cacao fields were cleared for the cultivation of this crop.

By the end of 1912 the banana industry had also failed on account of Panama Disease and planters had commenced to establish Liberian coffee on their estates. This plant thrives exceedingly well on the heavy clay soils of the coastal belt and at present is the staple agricultural product of the colony.

From 1900 onwards Witch-broom disease had been investigated by several workers, but, as the nature of the causative organism was not definitely established, adequate control measures were not universally put into operation and the disease slowly spread. In 1915, however, the problem was re-investigated by Prof. G. Stahel, who pointed out the dangers of depending entirely on a single crop—especially on one which in other countries had been subject to serious diseases, viz.: *Hemileia vestatrix*. It was considered that cacao (with witch-broom under control) would still prove a useful alternative crop to coffee, the more so as it was also highly suited to Suriname conditions. Prof. Stahel's investigation of the problem showed conclusively that the causal

organism of the disease (hitherto undiagnosed) was the Basidiomycete *Marasmius perniciosus*, nov. spec. whose fruiting bodies never occur on the green brooms, but quickly appear after decay has set in, especially in the rainy season. Remedial measures are fully discussed in his research publication (*Bull. No.* 33, *Dept. van den Landbouw*, 1915).

I was informed by Prof. Stahel that control measures by pruning cost about 10 cents Dutch (4 cents) per tree for the first pruning and subsequent prunings about 4 to 5 cents Dutch (2 cents) per tree—the whole control costs being within the economic limits of the industry. As a result of the extra attention and pruning the production per acre on the best properties actually increased. Thus, although an ever increasing number of cacao fields were being cut out and replanted with Liberian coffee, the cacao industry was placed on a better footing and served as a useful alternative crop to coffee until 1926 when the industry was almost completely wiped out. This was due, not to witch-broom as is frequently thought, but to a very severe drought. Table II shows the monthly rainfall from 1924 to 1928, and it will be seen that from the latter part of 1925 onwards a 6 months spell of drought was sustained.

TABLE II.

* RAINFALL AT PARAMARIBO IN INCHES.

Month.	1924.	1925.	1926.	1927.	1928.
January ..	5.00	3.69	**.48**	18.30	14.64
February ..	1.85	6.46	**.85**	5.52	5.93
March ..	1.59	6.63	**.77**	3.08	9.26
April ..	2.56	1.04	3.84	6.39	10.33
May ..	7.65	7.40	16.36	20.54	14.41
June ..	12.55	11.21	11.94	12.53	12.56
July ..	13.02	8.55	8.72	5.89	9.89
August ..	11.58	10.69	6.53	7.34	5.25
September	4.10	4.54	3.72	4.44	2.66
October ..	4.69	**.80**	3.80	2.59	3.69
November..	3.68	**.95**	3.34	3.80	4.65
December	10.66	**5.59**	10.40	12.33	9.87
Total ..	78.93	67.55	70.75	102.75	103.14

Much of the cacao was completely killed as a result. Liberian coffee was also affected by the prolonged drought, and planters thought that both crops had been ruined. The Liberian coffee, however, recovered and apart from temporary defoliation was greatly improved as the result of the soil cracking and aeration resulting from drought conditions. Cacao production in Suriname from 1911-1928 is shown in Table III. Since 1926 the remaining cacao has gradually been cut out and replaced by Liberian coffee.

* Average rainfall at Paramaribo=88 inches per annum.

TABLE III.

YIELD IN 100 KILOGRAMME.

Year.	Yield.	Year.	Yield.
1911	13,867	1920	16,023
1912	8,640	1921	15,799
1913	14,782	1922	13,606
1914	14,574	1923	11,606
1915	14,652	1924	7,951
1916	18,709	1925	6,956
1917	19,872	1926	1,402
1918	18,877	1927	2,107
1919	13,174	1928	2,049

During the writer's visit to Suriname some of the few remaining cacao fields were inspected. As no pruning had been practised for some time the amount of witch-broom was astonishing and could not fail to be noticed even by the most casual observer. Brooms in all stages of development could be picked in large quantities from every tree while some of the brown brooms collected at random carried as many as a dozen fructifications of *Marasmius*.

On some small cacao properties on the east bank of the Demerara River, British Guiana, similar extensive infections were observed. Such observations are impressive as they give some idea of the spread of the disease when no control is practised.

MANURES FOR MAIZE.

THE production of maize in South Africa has been more or less stationary, and this has led several investigators to the conclusion that these soils suffer from exhaustion. Part of this has been traced to the relatively small amount of artificial fertiliser used per acre and to the fact that a comparatively small amount of this grain is fed to cattle as concentrates and so returned to the soil as manure. Rotative cropping, too, is not usual. In experiments carried out during the last 8 years by the Transvaal University College Farm staff the plots sown continuously without fertiliser rarely returned more than 5 bags per acre. When 100 lb. of super. was added per annum, the yield averaged 8½ bags, while with the use of 3-year rotations, cowpeas being ploughed under after maize, it was found that over 9 bags per acre could be obtained. The data thus obtained seems to indicate that soils receiving no fertiliser are on the decline, and that those dressed annually in this way are more or less stationary. Those in which rotations are employed slowly increase production. Such increases have even been observed during drought periods. Cultivated land in the Transvaal now receives on an average 27 lb. of fertiliser per acre, while in the Orange Free State the average is only 6 lb. per acre.—(*The Fertiliser, Feeding Stuffs and Farm Supplies Journal*, Vol. XIV, No. 20.)

COPRA DRYING IN CEYLON.

[*The following extract from an article by Mr. F. A. Stockdale, is reproduced from the "Fiji Agricultural Journal" Vol.* II, *No.* 2, 1929.]

There is an indication that information is required in regard to the preparation of copra. Proposals for research work in some colonies have been considered and have been sanctioned. Mr. Sampson of Kew and the Imperial Institute have prepared memoranda on the question of copra drying, but it is thought that these memoranda can, with advantage, be supplemented by notes on the systems of copra preparation common to Ceylon.

The picking of coconuts takes place every 2 months in Ceylon. The method employed is either climbing the palms and cutting down the 2 lower bunches or, more commonly, from the ground by means of a sickle-shaped knife attached to the end of a long bamboo. On a well managed cultivation, the nuts of the 2 lower bunches are mature and are picked at each picking round, but, of course, judgment of maturity is essential and can only be settled by the pickers and by the supervisory staff. After harvesting, the nuts are heaped in central places in the plantation for 6 weeks to 2 months for drying, as this process facilitates the husking work and the subsequent extraction of the kernel. Husking is done on an iron spike firmly fixed in the ground and each husked nut is then split with a large knife or cutlass into halves across the shorter axis and placed on the ground to dry, concave side upwards. The kernel as it dries separates itself from the shell and can then be removed for the manufacture of copra. This initial drying to separate the kernel from the shell is usually done in the open and is reasonably rapid in sunny weather, but there are instances in wet districts when this initial separation of kernel from shell is effected in the drying sheds by means of heat.

In the dry districts of Ceylon, where there is certainty in regard to weather conditions, the copra is prepared by drying in the sun, but in the wetter districts, and these embrace the greater part of the coconut-growing areas, sun drying is only done in the drier months of the year, and during the wet weather, or during those months when the weather is uncertain, artificial drying is resorted to.

Artificial drying is done on a few larger estates in the upper storey of a properly constructed factory heated under the flooring of the upper floor by means of hot air drawn or driven through a series of galvanised iron pipings. The principle followed is similar to that adopted in the earlier days for heated tea factories and consists of a hot-air generating plant with engine-driven fans for providing for the circulation of the hot air. Such a system has recently been installed in the Central Experimental Station of the Department of Agriculture, Peradeniya.

The most general system of artificial drying and the one more suitable for small holdings, on account of its inexpensiveness, is the system of copra kilns or drying sheds. This kiln consists generally of a small shed made with brick walls and pillars surmounted by a galvanised roof, or with mud or wattle and mud (daub) walls surmounted by a roof made of plaited halved coconut-leaves (cadjans). In this shed is fixed a platform consisting of wooden slats—often made of the split stems of the areca nut palm. This platform is placed about 5 to 6 feet above the floor level and on it the copra is placed for drying. The height of the platform above the ground and the fire is a matter of practical importance and varies in different districts—probably on account of slightly varying average air temperature and on account of the often greatly varying degrees of humidity. On the mud floor of the shed dried half coconut shells are arranged in rows, the concave of the one being fitted into the convex of the other, and each row alternating thus:—

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  ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( A.—row 1.
B. ) ) ) ) ) ) ) ) ) ) ) ) ) ) ) ) ) ) )      row 2.
                    &c.
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These shells burn slowly and with practically no smoke, and, in order to secure an even burn over the whole building, row 1 would be lighted at A and row 2 at B., the burning thus taking place in every alternate row in opposite directions. The number of rows to be lighted and their position throughout the shed can be ascertained by experience. The half coconuts either shortly after being halved or, preferably, after they have dried in the sun for a few days, are placed on the slatted platform with the kernels still in the shells, or in good weather the kernels alone are put on the platform after having been removed from the shells. A thickness of 3 to 4 layers of such shells or kernels are placed on the platform, but it is wiser not to place them too thick. The fire of dried shells is made as described above. If kernels in the shells are placed on the platform they are ultimately removed from the shells and drying continued until it is completed, usually within 5 to 6 days. Finally, the dried copra is taken to a store and sorted over into different grades, No. 1 consisting of thick, clean and full half nuts, No. 2 consisting of thin, soft, full or broken half nuts, and No. 3 consisting of thin, soft dark pieces.

Experiments have been made by the Department of Agriculture in Ceylon with the object of improving copra drying sheds. These experiments included the provision of sliding trays instead of the fixed platform, or, alternatively, a sliding roof structure. The experimental developments were successful and good copra was produced in them, but they have not been adopted by copra producers, who are satisfied with their existing practices and types of drying houses.

COTTON NOTES.

BY S. C. HARLAND, D.SC. (Lond.),
Chief Geneticist, Trinidad Cotton Research Station.

The Causes of Fluctuation in Ginning Percentage.

Barritt (l.c) points out that while Balls accounted for the rise in ginning out-turn of later pickings as due to the effect of an increased food supply at the time of flowering, reflected in an increased number of hairs per seed, such an influence on the number of hairs actually differentiated seems hardly possible. A longer maturing period, however, such as might occur at the end of the season, would enable the lint hairs to continue the growth after the requirements of competing tissues have been satisfied, and the author believes that the rise of ginning out-turn in late autumn is due to the effect of nutrition. Turner (*J. Text. Inst.*, 1929, XX, pp. T 233-273) in a very valuable discussion of the effect of environment on ginning percentage also makes reference to the claim that high ginning percentage results from a favourable environment at the time of flowering. He examines the factors which may influence ginning percentage and his views may be summarised as follows:—

1. (*a*) If a definite percentage of epidermal cells may be differentiated into hairs and
   (*b*) if this percentage is always the same
   (*c*) and if the size of the ovule is constant—

Then all seeds would have the same number of hairs. But for some weeks after flowering the volume and the surface of the seed continuously increase, and the seeds which are arrested earliest in growth will have the greatest number of fibres per unit area. Thus, so long as the ratio, weight of small seed: weight of large seed, is less than the ratio of the unit fibre weight of small seed, to that of large seed, the ginning percentage of the small seed will be higher than that of the large seed.

2. The ratio of lint hairs to epidermal cells may change in such a way that in a small seed at the end of the season the percentage of differentiated lint hairs may become less.

3. The possibility that lint hairs are differentiated after fertilisation has not been fully explored. If, however, such differentiation were to take place it would account for the great variation in hair length found in even a small section of the seed coat. This variation, however, might equally well be accounted for by competition for electrolytes.

With (3) in view, Gulati (working in Turner's laboratory), made some tests to determine whether the numbers of epidermal and hair cells do increase after fertilization of the ovule. From his results Turner thinks there can hardly be any doubt that the numbers of both epidermal and hair cells increase largely up to 3 or 4 weeks after the flowering date. This conclusion, however, is difficult to reconcile with Barritt's anatomical observations. If Barritt is correct in assuming that the hair becomes constricted at an early period, it is clear that younger hairs could be recognised by differences in the degree of constriction and thickening. Since there is no anatomical evidence that hairs in all stages of development exist, the balance of evidence must remain with Balls, who stated that "there do not appear to be any further growth of epidermal cells into lint hairs after the first day, in spite of accepted statements to the contrary."

From the standpoint of genetics we may summarise the position thus:—

1. Mean weight of seed and mean weight of lint per seed are constant for a given pure line under optimum environmental conditions.

2. Since weight of lint per seed is determined by two factors—(*a*) number of hairs per seed and (*b*) mean hair weight, it follows that these also must be determined by hereditary factors.

3. Variations in ginning percentage may be due to hereditary or environmental factors acting on either seed weight, number of hair per seed, or hair weight. Some inter-correlation no doubt exists in all these 3 factors and the best way of studying such inter-correlation would be based on a study of a large number of pure lines.

* * *

The Structure of the Seed Coat of Cotton.

A considerable amount of work on this subject has already been done by Bowman, Flatters and Balls. All these authors agree that the seed coat is broadly differentiated into palisade cells, mesophyll and epidermis. Barritt (*Annals of Botany*, 1929, XLIII, 483-489) now describes the cell tissues in the epidermis of the seed of Egyptian cotton and proceeds to discuss the problem of the nutrition of the lint hairs in the light of his observations. He criticises the account given by Balls of the cytology of the palisade layer of the outer integument and confirms Miss Cleggs' discovery of stomata on the seed coat.

The outer epidermis shows the differentiation of the lint hairs immediately after flowering, and after 3 or 4 days the diameter of the hair is 4 times that of the basal portion attached to the epidermis. The base of the hair does not develop after differentiation and becomes subjected to considerable lateral pressure from the expanding neighbouring epidermal cells. The lumen of the hair becomes closed at an early stage, partly by this lateral pressure and partly by the thickening of the hair wall. The hair cells grow until they attain a length of 2,000 times their own diameter or more, and at the same time the palisade cells are elongating to 12 times their diameter. The fact that thickening proceeds simultaneously in hair cells, palisade layer, and epidermal cells, places the hairs at a disadvantage in the competition for food supplied by the vascular tissue. The author considers that part of the nutrition of the hairs and palisade cells is derived from the intercellular liquid in the mesophyll and boll cavity. When competition for food is severe it is clear that the lint hairs will fare

worst, and hairs with thin cell walls will be produced. There will also be competition among the hairs themselves for food and it follows that the fuzz hairs, being shorter and closer to the stomata will have an advantage over the longer lint hairs.

The author expresses surprise that in Egypt a correlation is supposed to exist between the presence of fuzz and good quality cotton, and even forms the basis for selection among persons of technical training. Ideas of this kind, however, should not be lightly dismissed. At this laboratory we have found that in certain crosses a strong positive correlation may exist between the amount of fuzz on the seed and the amount of lint, and it is conceivable that the opinion on the desirability of much fuzz on the seed may be based on its association with the abundance of lint rather than with its quality.

* * *

Chromosome Numbers.

Since the pioneer work of Denham at the Shirley Institute (*Ann. Bot.*, 1924, XXXVIII, pp. 433-8) several workers have made an examination of the chromosome numbers of various types of cotton. Cytological studies in relation to genetics are becoming so important that a new type of worker has made his appearance in the field—the Cyto-geneticist. His particular function is to explain abnormal genetic behaviour in terms of Cytology.

Banerji (*Annals of Botany*, 1929, XLIII, 603 to 607) presents the chromosome numbers of 4 types of acclimatised American cottons and 28 native types of the herbaceum, neglectum and indicum groups. The American cottons were found to contain 26 chromosomes and the Indian 13 (Haploid). This is in agreement with the numbers obtained by Denham. The practical outcome of this work is that plant-breeding work with cotton must confine itself to the 2 main groups, since hybrids between them are sterile. This sterility is now explicable on cytological grounds. A summary of what is known of the cytology of Gossypium may be useful for reference:—

Group.	*Chromosome Number.*	*Worker.*
New World, (Upland, Bourbon Peruvian)..	26	Denham, Beal, Banerji
Old World.		
Indian, Chinese, Burmese..	13	Denham, Banerji
G. tomentosum ..	26	Lans (this Laboratory)
G. Sturtii ..	26	Lans do.
G. Davidsonii ..	13	Lans do.
		Longley (communicated)
G. Stocksii ..	13	Youngman

Further work thus confirms the fact that the genus Gossypium contains 2 types of chromosome number.

Banerji did not encounter any appreciable difference in the size of the chromosomes, though in some cases 1 slightly bigger chromosome was met with.

Beal (*La Cellule*, 1928, XXXVIII, pp. 245-268), has also confirmed the chromosome number of New World Cottons and observed great variation in the size of the chromosomes—a variation ranging from very tiny elements to 5 to 6 large chromosomes.

* * *

The Early History of Cotton.

Although it is known that the use of cotton as a textile material was known in very early times in India, the earliest authenticated reference to its use is no earlier than 800 B.C.—in the Hindu Rig Veda. All doubt as to whether cotton was used in early times has now been settled by the discovery at Mohenjo-daro, in the valley of the Indus, of fragments of cotton materials. According to Sir John Marshall the date of the buildings at Mohenjo-daro can be put between 3500 and 2500 B.C.

Gulati and Turner (*Indian Central Cotton Committee*, 1928, Bul. No. 17, Tech. Series No. 12) describe these cotton materials in detail. An estimation of the hair weight was made and it was found that the value was quite different from present-day American Upland, but corresponded closely with the coarsest varieties of Indian Cotton of the arboreum type.

RUBBER TAPPING EXPERIMENTS.

THE following is a summary of two papers on rubber tapping experiments, which have recently been reviewed by Dr. C. J. J. van Hall in the *International Review of Agriculture*, Part 1, No. 4. Dr. van Hall says that in systems of tapping, over one-half circumference, compared by Bally [1] in Malang (East Java) it was found that in newly tapped fields there was no difference between the yield obtained by periodical tapping and the 1 month system (1 month tapping, 1 month rest) and the alternate day tapping. After 22 months the periodical tapping with the 1 month system was altered to the 2 weeks periodical system, and from the third month the plots with alternate fortnight tapping yielded about 30 per cent. more than the alternate day tapped plots.

In another experiment [1] the methods of alternate month tapping and alternate day tapping were once more compared, with the difference that tapping was done over one-third circumference in fields which were in their 4th and 5th tapping year. The experiment which lasted for 3 years revealed that while the yield of the alternate day tapped trees decreased from 100 in 1925 to 84.7 in 1926, and 91.5 in 1927, the alternate month tapping increased the yield as follows: 100, 107.0, 130.8. In a third experiment where alternate day tapping was compared with 20-days periodical tapping, no difference in yield was found.

Van Baalen (2) who carried out very careful and extensive tapping experiments from April, 1925, to June, 1928, compared the following systems: (*a*) Alternate day tapping over one-half circumference; (*b*) alternate day over one-third circumference; (*c*) every third-day over one-half circumference; (*d*) 20-days periodical tapping over one-half circumference; (*e*) one month periodical tapping over one-third circumference. These experiments revealed that the 20-days periodical system over one-half circumference and the alternate day tapping over one-half circumference gave a yield 20 per cent. higher than the 30-days periodical and the alternate day system over one-third circumference, though in the last of the three experimental years the results of tapping over one-third circumference were slightly improving.

Periodical tapping both when applied over one-third and over one-half circumference gave higher yields (3 per cent. more) than alternate day tapping over one-third and over one-half circumference. These results are similar to those obtained by Maas (*Archief voor de Rubbercultuur*, 1925 and 1926) but do not tally with Bally (1).

With the one month periodical system, the highest daily yield was obtained on the 24th day, with the 20-day periodical system, on the 12th day. Brown bast disease was more prevalent on trees tapped over one-half circumference than on those tapped over one-third circumference. The disease was checked by reducing the cut to half its length, and the tapping continued. Diseased trees treated thus produced 80 to 90 per cent. of the yield of healthy trees.

It was concluded that alternate day tapping or 20-days periodical tapping were the most economical systems.

(1) Bally, Dr. W.—Tapproeven in het ressort van het proefstation Malang.—*Archief voor de Rubbercultuur in Nederlandsch*—Indië, Vol. XII, No. 4, p. 268, Batavia, 1928.

(2) Van Baalen, J.—Resultaten, verkregen met vyf verschillerde tapsystemen.—*Bergcultures*, Vol.CCCLI, No. 14, p. 351, Batavia, 1928.

PIQUI-A FRUIT OILS.

According to an article by C. D. V. Georgi in Vol. XVII No. 6 of *The Malayan Agricultural Journal*, Piqui-a, *Caryocar villosum*, is a large tree indigenous to Brazil which was introduced about nine years ago into Malaya for planting under estate conditions. The trees now growing in this Colony are about 50 feet high with an approximately equal spread of branches. They flower between the months of March and June and their fruits which ripen during October and November contain two oils, one present in the pericarp of the seed and the other in the kernel.

Fruit.

The sub-drupaceous fruits, which may contain as many as three or four seeds, are globular in shape, measure 4 to 4½ inches in cross section and approximate in size to large oranges. When there are two or more seeds present the fruit tends to assume an oblong shape. The outer layer of the pericarp, which is approximately ½ inch in thickness, is light brown in colour and smooth in texture, it contains a relatively high percentage of a tannin of a pyrogallol type, amounting to approximately 9.0 per cent. on the fresh material, equivalent to 33 per cent. on a moisture-free basis.

The seeds, which vary from 2¼ to 2½ inches in length, are flattened at the base and rounded at the apex. The inner layer of the pericarp surrounding each seed and approximately ⅛ to ¼ inch thick is yellow in colour and contains oil. The material composing this layer darkens on exposure to air.

The shell of the nut varies in thickness from approximately ¼ inch on the sides to ½ inch at the apex, the shell itself being composed of two layers, an outer layer full of brittle spicules and a hard thin inner layer. The kernel, the flesh of which is white is about 2 inches long and ¾ inch thick and is covered with a dark brown testa.

The approximate composition of the inner layer of the pericarp and of the kernel of the fruit which has an average weight of about 300 grammes is as follows :—

(1) *Inner layer of pericarp.*	
Moisture	.. 34.4
Oil (petroleum ether extract)	.. 47.4
Residue (by difference) ..	.. 18.2
Oil (calculated on moisture-free basis)	72.3
(2) *Kernel.*	
Moisture	.. 26.6
Oil (chloroform extract) ..	.. 45.1
Residue (by difference) ..	.. 28.3
Oil (calculated on moisture-free basis)	61.4

Oils characteristics.

The pericarp oil is reddish-orange in colour and has an agreeable odour. When cooled a few degrees below the normal atmospheric temperature it solidifies to a fat which is somewhat lighter in colour.

The kernel oil is yellowish in colour and semi-solid at ordinary temperature. It is odourless when cold, but develops a slightly unpleasant odour on heating.

Analytical results show that the constants of the pericarp oil agree closely with those for palm oil and it appears probable therefore that piqui-a pericarp oil can be used for similar purposes. The oil is easily bleached and high quality oil would therefore be suitable as a basis in the preparation of edible fats. A series of experiments demonstrated however that in the preparation of high quality oil it would be necessary to treat the ripe fruits without delay owing to the presence of an enzyme causing free fatty acids to develop on storage.

The kernel oil, which is similar to the oil from another species *Caryocar tomentosun*, could also be used for edible purposes. The kernels of this species and the allied species, *Caryocar nuciferur*, are highly esteemed as dessert nuts in the West Indies and South America.

TROPICAL WORLD NOTES.

Togoland.

Togoland * is the smallest of all the British Mandated territories and it possesses no sea coasts, access being obtained over the Gold Coast Colony and French Togoland. The chief article exported is cocoa which was valued at £200,337 in 1928. The natural outlet for this crop is *via* the Lome-Palime Railway while another inducement for its export through this channel is the "card" system which was introduced by the French. Under this system a certain tonnage of cocoa produced in British Togoland is allowed to enter France free of duty. This tonnage is checked by cards which are issued by the French Government to individual cocoa farmers, and which specify the quantity of cocoa that they may export to French Togoland, free of duty.

Agricultural investigations in Togoland have been conducted by a number of separate divisions of the Gold Coast Department of Agriculture which has recently been reorganised on a subject instead of a territorial basis. The Kpeve Station which constitutes one of the major investigational stations of the Department has been maintained and its cultivated area extended during the year. On the cocoa plots tests have included manurial and cultivation trials, key-tree records and individual tree records. Daily records and measurements have been made of flowering, flower-shedding, fruit-setting and fruit development, and certain selected trees were selfed or hybridised to supply material for progeny plots. Investigations have also been designed to estimate the seasonal variation in the yield of trees in terms of pod numbers, and value as dry cocoa, the relationship between yields and climatic factors, and the relationship between losses on crop and climatic or physiological factors.

Considerable attention has also been devoted to the cotton crop. Selection work has been continued and of the many varieties tested, the chief were American Upland, Webber, Sakel, Ishan and Sonko.

* * *

The Seychelles.

The Director of Agriculture in his Report for 1928 states that a record crop of coconuts (38,910,000 nuts) was harvested, principally owing to a heavier rainfall. There were severe attacks by scale insects which in some localities reduced the crop by 50 per cent. These attacks are said to be due to inferior soil conditions, lack of drainage and plant food. Specially is this apparent on the mountain slopes where ravages are more severe and on the coral flats which remain flooded for a long time during the rainy season. Birds and predaceous insects have also disappeared through the destruction of wooded jungle by planters in search of firewood for their distilleries. Fortunately, however, some of the scale insects are being kept under control by entomogenous fungi, most of which were discovered side by side with coccidae. Another severe pest is the melitomma beetle to which the death of 90 per cent. of the palms is attributed. This insect is being controlled by walling in or earthing up the base of the tree trunks.

Vanilla which used to be grown as an intercalary crop between the rows of coconut trees, has been replaced by perfume plants, chiefly patchouli, which, to give a profitable crop has to be manured heavily. Greater use of artificials and of cover crops is being made with a view to increasing soil fertility, checking erosion and restoring humus to the worn out lands. The production of cinnamon has been stimulated instead of vanilla which is being gradually abandoned owing to its being driven out of the market by vanillin, a cheaper substitute for Eugenol. Cinnamon is chiefly grown on the high mountain sides while patchouli has given good results on the flats. Other essential crops grown are lemon grass, citronella and basilic. Experiments are also being carried out with palmarosa grass, *Cananga odorata* and peppermint. The price of cinnamon leaf oil is at present very remunerative, but it is subject to fluctuations which are not understood. Owing, however, to the great similarity between clove leaf oil and cinnamon leaf oil it is very likely that the Seychelles will benefit from the efforts made in other Colonies, such as Zanzibar, to protect their clove industries.

* * *

British Cameroons.

The 1928 Report (1) for the colony reveals that the three chief exports during the year were dried bananas, rubber and cocoa. As compared with 1927, the weight of dried bananas was doubled while rubber showed an increase of nearly 1 million lb., increases which can be accounted by renewed activities on the part of plantation companies. The fresh banana trade is also showing signs of revival. The scheme to improve the system of drying native cocoa (2) which at first met with some opposition has now, under the supervision of a Superintendent of Agriculture, proved successful. Eight fermenting houses were erected and in several cases the houses first built had to be enlarged to cope with the demands made on them. The cocoa had not been sold at the end of the year so exact figures cannot be given. It is estimated, however, that £3,744 will be available for distribution as a result of the sale of 104 tons of dry cocoa. It is hoped also that low prices will not act as a deterrent to production and again give rise to distrust of a scheme working for improving the quality of cocoa produced. It is certain, however, that the price which will be obtained is probably quite £10 a ton more than would have been received had the farmers sold their cocoa themselves. A Farmers' Society at Kumba has been formed with the object of improving native methods of agriculture.

* Togoland under British Mandate Colonial Report, 1928.

(1) Colonial Report, British Cameroons, 1928.
(2) *Tropical Agriculture*, Vol. V. No. 12.

Afghanistan.

The Institute of Applied Botany (Leningrad) sent an expedition to Afghanistan in 1924, consisting of the Director of the Institute, Prof. N. L. Vavilov, the engineer-agronomist, D. D. Bukinich, and the agronomist, V. N. Lebedev. The principal purposes of the expendition* were; (1) To investigate and collect plants cultivated in the country; (2) to ascertain the regularities in the distribution of crops and their varieties over the slopes of the Hindu Kush; (3) to investigate the technique of local agriculture, the irrigation in particular; (4) to gather information as to the agricultural resources, especially as regards cotton-growing.

A characteristic feature of Afghanistan is the co-existence of extremely primitive forms of husbandry with rather intensive forms of farming in the oases, which may be observed in the valley of Hari-Rud, especially near Herat. Agriculture of the valley is characterised by extraordinary diversity of crops. The methods of irrigation are thoroughly worked out, cereals are harvested twice a year, and manuring is extensively practised.

The most isolated and unexplored region of Afghanistan is Kafiristan. High up in the thickets of mountain forests, the population practises a sedentary type of agriculture. Fearing the hostility of neighbours, the agricultural population of Kafiristan lives on inaccessible heights. Mills are found everywhere; the plough —where possible. In places some excellently cultivated terraces of crops may be observed. Every foot of soil is utilised.

The first place in cultivation in Afghanistan is taken by wheat, the second by barley, the third by rice. Then follow the Leguminosae, and the next place is occupied by cotton. A considerable acreage is under alfalfa and *Trifolium resupinatum*. Hull-less barley is grown at an elevation of 3,000 m.-3,400 m.; hulled barley, peas, spring rye, and *Ervum Ervilia* 2,500 m.-3.000 m. which is also the zone of spring cereals and of grain Leguminosae. At 1,500 m.-2,000 m., the majority of cultivated plants appear. This is the zone of maximum diversity of crops and varieties. Grapes may be regarded as the determining plant of the zone; 1,000 m-1,500 m. is the principal zone of cotton, rice, Cucurbitaceae. Below 1,000 m. sub-tropical crops thrive; sugar-cane, oranges, the date palm.

The investigation of varietal diversity of cultivated plants has shown that Afghanistan and adjacent countries, especially the North-western Provinces of India, is one of the most important primary world agricultural centres, where the varieties of numerous plants have originated. This is objectively proved by varietal diversity of a series of crop plants and by the coincidence of the area of the varietal diversity of many most important European crops. For example, as regards the diversity of club wheats and soft wheats generally, Afghanistan occupies the first place in the world. Though the varietal diversity of cultivated barley is poor, *Hordeum spontaneum* grows abundantly in northern Afghanistan, while eastern Afghanistan, and the adjacent regions of north-western India, are the world centre where the maximum of characteristics of the most important Leguminosae are found. The region is probably the centre of origin of these crops. Many endemic forms have been found. In regard to flax, Afghanistan undoubtedly borders on one of the principal centres, where the forms of this crop have originated. Hemp on south-eastern Afghanistan represents the pro-genital type of *Cannabis indica* Lam. A series of oleiferous Cruciferae have evidently imdependently become cultivated field crops of Afghanistan and adjacent countries. Northern Afghanistan is the realm of wild melon, with all transitions to the cultivated type, and there is no doubt that Afghanistan is a part of the primary area in which cultivated melon has originated. The extraordinary wealth of varieties of carrots, turnips, and radishes show that Afghanistan is the primary world centre of these crops. The same may be observed with regard to other less important crops, such as spinach.

The botanico-geographical facts definitely direct attention to the south-eastern part of Afghanistan and regions towards the Punjab. It is in this region that the complex of genes of many European-Asiatic crops have been found. Here, and in the adjacent districts, a series of crops have originated, a fact proved by the presence of all stages of evolution. The above-mentioned region includes the Punjab. It is to this small part of India that we turn for the solution of the genesis of the above cultivated plants and not to the rest of India, which has no bearing on the majority of these crops. In regard to climate, relief, and crops, the North-western Provinces form one undivided whole with Afghanistan. The remaining part of India differs sharply from Afghanistan in climate and soil.

* Supplement 33rd to the *Bulletin of Applied Botany of Genetics and Plant Breeding*, Agricultural, Afghanistan. By Prof. N. I. Vavilov and D. D. Bukinich. (Leningad.)

* * *

St. Vincent.

The trade* of St. Vincent for 1928 may be compared as follows with that of 1927, a reduction in yield of Sea Island cotton owing to heavy attacks of cotton worm and rot, an increase of over ½ a million lb. in the arrowroot crop and of over 1 million lb. in the sugar crop. There was also a steady increase in the production and export of copra. It is reported that the United States is absorbing larger quantities of arrowroot and that the campaign inaugurated by the St. Vincent Arrowroot Growers and Exports Association through the medium of the West India Committee is beginning to bear good fruit. The Empire Marketing Board have also given valuable assistance both by a money grant and propaganda work.

* St. Vincent 1928 Colonial Report No. 1436.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Spontaneous Decomposition of Sugar Molasses.

C. A. BROWNE [1], *Ind. and Eng. Chem.*, 1929, 21, No. 6, 600-606.

IN January, 1914, the late G. L. Spencer called the attention of the author, at Central Constancia, Cuba, to a peculiar type of deterioration in tanks of stored molasses. This molasses, which was the final product obtained by the defecation process, was undergoing a constant, gradual loss in sucrose, although there were no apparent evidences of fermentation by yeasts or other biological agencies. The high concentration of the molasses was, in fact, so unfavourable to the growth of micro-organisms that it seemed necessary to attribute the decomposition of the product to other causes. Samples of about 4 kg. each were accordingly drawn from two tanks of deteriorating molasses and sent to the New York Sugar Trade Laboratory, where they were examined by the writer at intervals over a course of 9 years. The results of the analyses of the 2 samples of molasses show as a whole from year to year: (1) a progressive lowering in the polarization; (2) a constantly increasing loss of sucrose; (3) a slow irregular increase in the percentage of invert sugar; (4) a constantly increasing loss in the total sugars after inversion; (5) a constant increase in the percentage of organic non-sugars. Bacteriological examination of the samples in 1914 and on various occasions until 1928, failed to reveal the presence of yeasts, moulds, bacteria, and other micro-organisms. This would indicate that the decomposition must be ascribed to chemical and not to biological causes. In the writer's opinion the deterioration must be regarded as a very slow retarded type of "hot room" or "froth" fermentation of the sugar-house, in which carbon dioxide, formic acid, acetic acid, and pungent acrid fumes of unknown composition are evolved, together with considerable heat. Another "fermentation" is that sometimes observed in tanks of molasses, also attended by CO_2 evolution, not only as froth on the surface, but also as gas pockets at various depths of the tank (this introducing a considerable error into the measurement of quantity by volume). Similar charges have been observed by the writers in bottle samples which after long storage were transformed into dark porous masses resembling carbonized sugar.

Two explanations of this froth fermentation have been proposed. The first is the formation of glucic acid by the action of the lime used in defecation on the reducing sugars of the cane juice, and this theory is supported by Prinsen Geerligs [2], who showed the content of this compound in cane molasses to be from 0.31 to 7.29 per cent. Winter [3] isolated a crystalline preparation of glucic acid, but the product was so unstable and impure that nothing definite could be ascertained regarding its chemical constitution. The second explanation is the formation of unstable compounds by the action of the amino-acids of the molasses on the reducing sugars, which reaction has been studied by Maillard [4]. Lafar [5] believes this reaction to account for this sugar-house phenomenon. In the opinion of the author, however, while the reaction between amino compounds and reducing sugars no doubt accounts for a part of the losses in total sugars which were noted, the chief cause of the spontaneous deterioration of sugar-cane molasses would appear to be the reaction of unstable organic substances, originally produced by the action of lime upon invert sugar, with further quantities of the reducing sugars in molasses. In confirmation of this explanation, it may be said that it is more particularly the molasses obtained by the defecation process, especially where lime was used in excess, that show a susceptibility towards spontaneous decomposition. Cane table syrups produced by a clarification with lime are also generally the ones that show after sterilization spontaneous decomposition in cans. It should also be stated that the spontaneous destruction of sugars and the formation of organic non-sugars were still found to proceed in the 2 samples of deteriorated molasses after the disappearance of the "ninhydrin" reaction for amino compounds. Furthermore, the amino acid-reducing sugar reaction fails to explain the formation of the considerable quantities of formic and acetic acids, which are particularly abundant in cane syrup and molasses that have undergone spontaneous decomposition.—(*I. S. J.* 31, 369, p. 509.)

REFERENCES.

(1) I.S.J., 1928, 559.
(2) I.S.J., 1893, 407.
(3) *Zeitsch Ver. Ruben-Zuckerind.*, 1894, 1049.
(4) *Comptes rendues*, 1911, 153, 1079.
(5) I.S.J., 1914, 184.

NEW GUINEA EXPEDITION.

IN an article entitled "Into Primeval Papua by Seaplane," Dr. E. W. Brandes in the *National Geographic Magazine* for September, 1929, publishes an absorbing account of the New Guinea Expedition, illustrated by a good number of photographs of considerable interest. "Neolithic man," he says, "has not vanished entirely. He lives now as primitively as he did uncounted thousands of years ago." His account of the various types of peoples encountered by the "great hawk" and the extraordinary customs of most of them, makes a most entertaining adventure story. In this account, however, very little is said regarding the various canes found.—(*International Sugar Journal*, Vol. XXXI, No. 369.)

NEW CHEMISTRY BUILDING.

Research Laboratory.

Balance Room.

NEW CHEMISTRY BUILDING.

Lecturer's Room.

One of the Lecture Rooms.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Waste Products of the Wood Industry.

During the Forestry Week held in Stockholm last March, Erik Hägglund, of Aabo, Finland, presented a very interesting paper on the chemical utilization of waste products from sawmills and pulp and paper factories. In the sawmills, only about 51 per cent. of the log weight is utilized in the form of sawn materials, 44 per cent. being obtained in various waste products. At best 24 per cent. can be utilized as chippings for sulphate cellulose; but, at present only 3 to 4 per cent. is used for this purpose. The remainder is chiefly used as fuel for steam boilers. Among the possible ways of utilizing sawmill wastes, sugarification by hydrolysis is considered the most promising. The wood sugar can be used with advantage as cattle fodder. It is also possible to produce liquid fuel from wood waste by high-pressure hydrogenation.

The utilization of the waste liquors from cellulose factories is also an important problem. A remarkable development in this connection is the production of pressed yeast from sulphite liquor. This commodity is likely to achieve importance if the product can be manufactured at a cost which makes it saleable as fodder yeast. A suitable mixture of fodder yeast and wood sugar might form a satisfactory substitute for fodder cakes. Since, however, only about 10 per cent. of the organic matter contained in the waste liquor can be recovered by fermentation processes, the immediate problem is to increase the output of pulp and thereby directly reduce the loss of wood substance. The waste liquors obtained in the sulphate or soda-cellulose factories can be treated by destructive distillation or by heating under high pressure to recover part of the organic substances in the form of acetone, methanol, acetic acid, oils and tar.—(*Indus. Eng. Chem., News Edit.*, Vol. VII, No 11, p. 7.)

* * *

Recent Researches on Pectin.

The investigations of Dr. F. W. Norris of the British School of Malting at Birmingham, have demonstrated that the predominating unit in soluble pectin, such as occurs in citrus fruit-juices, is trimethyl pectic acid. This substance has actually been identified in orange-juice. Erlich early resolved pectic acid into arabinose, galactose and tetragalacturonic acid. An attempt by Ling and his co-workers to remove the acid groups in order to produce a hemicellulose gave, unexpectedly, pure galacto-galacturonic acid. Professor Shryver and his colleagues at the Imperial College in London, obtained a hemicellulose from pectic acid by treatment with alkali. Researches on the constitution of pectins and hemicelluloses have led to the suggestion that these compounds should be included in one big group, to which the name polyuronides has recently been applied by Shryver.

The uses of Sawdust.

Indications of a possible future use for sawdust that now makes useless and troublesome mountains around sawmills were contained in a paper presented by Professor W. H. Peterson, R. J. Allgeier and Professor E. B. Fred, of the University of Wisconsin. In a co-operative chemical-bacteriological research programme, they have discovered how to make the powdery wood waste into acetic acid, the active principle of vinegar, and lactic acid, which is what makes sour milk sour. Both these acids have industrial uses that render their domestic significance an entirely secondary matter.

Three steps were involved in turning wood into acid. The first was turning it into sugar, which was done by the old familiar method of treating it with a strong chemical, such as sulphuric or hydrochloric acid. Then the pulp was further treated with a carbohydrate-converting enzyme, contained in malt sprouts. Finally, the process was completed by the addition of a micro-organism that has the power to ferment both hexose and pentose sugars into acid. From 80 to 90 per cent. of the sugar present was fermented, the resulting mixture of acids consisting of 10 parts of lactic to one of acetic. Wood sugar produced by the Bergius process in Germany fermented equally well and gave the same yield and ratio of products. —(*Science Supplement*, Vol. LXX, No. 1811.)

* * *

Cellulose from Sugar-Cane.

The process for preparing cellulose from cane megass is modified, according to a recent patent, as follows:—The megass, preferably after drying and mechanically removing dirt, parenchyma, &c., is softened by treatment at not above 90°C. with 10 times its weight of a solution containing 1.25 per cent. of lime and 0.125 per cent. of sodium sulphite. This liquor is then removed and replaced by a solution containing 2 per cent. of caustic soda, 0.5 per cent. of caustic potash, and 1 per cent. of sodium sulphite, in which the material is digested at 2 to 5 atmospheres for 4 to 6 hours to dissolve fats and resins, and to emulsify waxes. After reducing the pressure, a solution containing 2.5 per cent. of a fatty soap is added, and the cooking continued for another half hour to ensure complete emulsification of all products removed by the alkaline digestion. The liquor is then removed and the cellulose thoroughly washed with hot water. The product may be bleached and used in the paper or artificial silk industry.—(*Journal of the Society of Chemical Industry*, Vol. XLVIII, No. 35.)

* * *

Paper from bamboo produced in India.

A process developed by experiments in India by which white paper of an excellent quality can be made from bamboo is attracting interest, according to W. H. Minor, vice-consul at Calcutta. Some progress is already reported in the commercial application of the new material for paper, and the formation of a company is being considered in England.—(*Indus. Eng. Chem., News Edit.*, Vol. VII, No. 14, p. 6.)

COLLEGE NEWS.

The Principal returned from Barbados, where he attended the West Indian Sugar Commission, by s.s. *Inanda* on 26th October.

* * *

Messrs. C. A. Thorold and J. West, both of whom are second year Colonial Office students returned from England by s.s. *Magdalena* on 20th October.

* * *

We offer our hearty congratulations to Mr. H. L. Grogan who has been awarded the Stephens' Gold Medal for 1929 for being the most proficient student of the 3 years Diploma Course.

* * *

Mr. C. E. Douglas, who has been commissioned by the Empire Marketing Board to report on the rice industry in British Guiana, arrived on 26th October and spent 2 days at the College as the guest of the Principal.

* * *

Dr. H. R. Briton-Jones, Professor of Mycology and Bacteriology and Mrs. Briton-Jones returned from England by s.s. *Ariguani* on 19th October. Dr. Briton-Jones, as already announced, recently attended the Imperial Mycological Conference.

* * *

Mr. H. McLuskie who has been appointed Agricultural Superintendent, British Guiana, and who is taking a special course at the College, arrived by s.s. *Carare* on 2nd November. Mrs. G. Evans and Mrs. R. E. Hunter returned to Trinidad by the same opportunity.

* * *

A meeting of the Trinidad Science Club was held on 7th November when Captain Watson delivered an address, illustrated by a film, on the Waterloo Estates and Sugar Factory. At this meeting Mr. G. Wright the retiring Secretary, was presented with a silver cigarette box in recognition of his services to the Club during the past 3 years.

* * *

Amongst recent visitors to the College were Sir Esmé Howard, G.C.B., G.C.M.G., K.C.B., British Ambassador at Washington; Sir Frederick Seton-James, K.B.E., C.M.G., Governor of Grenada; Professor Sydney Dash, B.S.A., Director of Agriculture, British Guiana; Dr. R. B. Hill of the Rockefeller Foundation and Mrs. Hill; Dr. and Mrs. E. G. Holt, Pittsburg, Pa.; and Mr. A. L. Rhodes, Government Printer, Trinidad.

* * *

Mr. H.W. Simmonds, Government Entomologist, Fiji, arrived at the College on 21st October. He will undertake at the request of the Fiji Government, certain preliminary investigations into the possibility of the biological control by means of a certain species of Thrips (*Liothrips urichi*) of *Clidemia hirta*. This weed has become established in Fiji, where it is occupying large areas of valuable land. Mr. Simmonds' object is to collect colonies of these Thrips and to convey them eventually to Fiji where, by releasing them, it is hoped that they will prove instrumental in keeping *Clidemia hirta* under control.

The College authorities are endeavouring to co-operate with him in every way, so as to make his mission a success. Mr. Simmonds will probably be at the College for several months.

IMPERIAL CHEMICAL INDUSTRIES.

We have great pleasure in announcing that Imperial Chemical Industries have consented to contribute £1,000 for the next five years to the funds of the Imperial College of Tropical Agriculture.

EXAMINATION RESULTS.

At a meeting of the Academic Board held on 7th November, the following Students were awarded the Associateship of the Imperial College of Tropical Agriculture :—

Mr. C. G. Akhurst, A.R.C.S., B.SC. (London).
Mr. W. Cook, Nat. Sc. Trip., pts. I and II (Cantab).
Mr. C. W. L. Fishlock, B.SC., Agric. (Reading and London).
Mr. A. V. Gibberd, N.D.A., N.D.D., Dip. Agric. (Reading).
Mr. T. R. Hayes, M.SC., Tech. (Manchester).
Mr. R. L. Knight, B.SC., Agric. (London).
Mr. R. Leach, B.A. (Oxon.).
Mr. A. C. Maher, B.A., Dip. Agric. (Cantab).
Mr. J. A. McDonald.
Mr. A. N. Prentice, B.SC. Agric. (Edinburgh).
Mr. A. Pickles, 1st Class Hons. Zoology (Leeds).
Mr. J. Robertson, B.SC., Agric. (Aberdeen).
Mr. R. W. Stuckey, M.A. (Cantab), B.S.A. (McGill).
Mr. R. Turner, B.SC., Agric. (Edinburgh).
Mr. A. S. Thomas, B.SC., Hort. (London).
Mr. A. E. Trotman, N.D.A., Dip. Agric. (Harper Adams).
Mr. C. A. Thorold, B.A. (Oxon.).
Mr. R. G. H. Wilshaw, B.SC., B.A. (Oxon.).
Captain J. Mc N. Wingate.
Mr. J. Wright, 1st Class Hons. Botany (St. Andrews).
Mr. J. West, B.S.A. (McGill).

ACKNOWLEDGMENT.

We have to acknowledge, with thanks, the gift of a collection of valuable publications presented to the Library by Sir David Prain, and also a set of leaflets, complete with loose-leaf binder, "Concerning Sugar," presented by the United States Beet Sugar Association.

THE NEW CHEMISTRY BUILDING.

THE new chemistry building was completed in August, 1929, and was immediately occupied by the Department of Chemistry and Soil Science. The photographs accompanying this issue of *Tropical Agriculture* give an accurate impression of the main features of the building. The structure is of reinforced concrete, with floors and interior walls of concrete, and ceilings of *Cellotex* board. The roof and window hoods are galvanised iron.

There are two floors, of which half of the one in the basement is occupied by the Department of Sugar Technology. This section comprises a lecture room, a research laboratory, a students' laboratory, and two offices. The rest of the basement floor is occupied by a soils laboratory for special work in connection with the Trinidad Froghopper Committee, and by a store room and a machine room for preparing samples.

The upper floor is divided into a Diploma Students' laboratory (20 x 50 feet) which will accommodate 32 students, two lecture rooms (each 30 x 20 feet), a general research laboratory (30 x 30 feet), private rooms (each 20 x 20 feet) for professor and lecturer, a balance room, a library and a research student's room (each 10 x 20 feet).

The laboratories are furnished with wooden benches, cupboards and shelves made in the College workshops. The fuel gas supply is manufactured by the Mansfield "cracking" process from crude oil. Each room possesses its own gas, water, electricity, and waste service mains, which may be tapped at one or more points and brought to the benches, sinks, &c. along pipe lines.

Ventilation is effected through wide passages which divide the building on each floor longitudinally into two. Within the rooms large moveable window sashes, hinged along their horizontal edges, and flanked by jalousie frames allow free movement of air without permitting draughts.

The building is eminently suited to the purpose for which it was designed, and reflects great credit on the College Engineer who designed it and superintended its erection.

F. H.

BOOKS RECEIVED.

WE have to acknowledge the receipt of the following books:—

AGRICULTURE.

The World's Grasses. J. W. Bews. p. 408. *Longmans Green & Co., Ltd.*, 21s.

GENERAL.

Nelson's West Indian Arithmetics, Book IV, Pupil and Teacher's Books. J. O. Cutteridge. *Thos. Nelson & Sons Ltd.*, 3s. 7d.

MR. G. WRIGHT, M. Com.

An Appreciation.

MR. WRIGHT who recently concluded his 3-years' appointment as Lecturer in Economics at the Imperial College of Tropical Agriculture, graduated in Commerce at Leeds. During his tenure of office, Mr. Wright's activities were never entirely confined to the teaching of economics. He will be remembered, particularly, by his excellent work in the Library, which, when he arrived was in a state of chaos, and it was largely due to his efforts that it has been made of real service to the staff and students of the College. He also acted on several occasions as Editor of *Tropical Agriculture* and was mainly responsible for the publication of the *Sugar Supplement* of 1927. In the sphere of Economics he prepared an economic survey of St. Vincent which earned him the M.Com. Degree of the University of Leeds. His investigations in Trinidad were mainly identified with an economic survey of peasant cacao cultivation which he was, unfortunately, not able to complete. Mr. Wright acted as the Honorary Secretary of the Trinidad Science Club from its inception and the high standard and wide variety of the papers read is a tribute to his energy and breadth of outlook. He has now joined the Trinidad Trading Company as Assistant Accountant and our best wishes go with him in the new work which he has undertaken.

APPOINTMENTS.

THE following appointments of Students in residence at the College during the session 1928-29 have been notified by the Secretary of State for the Colonies:—

Mr. C. W. Lynn, Assistant Superintendent of Agriculture, Gold Coast.

Mr. A. S. Thomas, Assistant Superintendent of Agriculture, Gold Coast.

Mr. J. M. Ward, Assistant Superintendent, Agricultural Department, Gold Coast.

Mr. A. C. Maher, Assistant Agricultural Officer, Kenya.

Mr. A. E. Trotman, Superintendent of Agriculture, Nigeria.

Mr. R. Turner, Superintendent of Agriculture, Nigeria.

Mr. R. Leach, Mycologist, Nyasaland.

Mr. R. W. Stuckey, Agricultural Officer, Uganda.

CANES IN JAVA.

IN Java the total area under cultivation for the 1929 crop is 197,085 hectares or 2,172 hectares more than last year(1). Average figures for the cane varieties planted are as follows: P.O.J. 2878, 93 per cent.; E.H. 28, 2.50; other P.O.J's. than 2878, 2.00; D.I. 52, 1.75; E.K. 2, 0.25; E. K. Madoe, 0.25; and miscellaneous, 0.25 per cent.

(1) *Archief Mededeelingen* No. 9.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have been as follows:

	Foreign.		Preferential	
	s.	d.	s.	d.
11th October ..	9	3	13	0¾
16th October ..	9	0¾	13	0
22nd October ..	9	0	13	0
24th October ..	9	0	12	10½
29th October ..	8	10½	12	10½
5th November ..	8	10½	12	7½
15th November ..	8	6	12	7½

According to *C. Czarnikow, Ltd.* the chief feature of interest at the beginning of October was the publication of Licht's estimate of the whole European crop for the current season which showed a total deficit, compared with 1928-29 of 313,327 tons or 3.66 per cent. Licht in arriving at this figure took into consideration the severe drought which has prevailed in many parts, the presence of insect pests and the fact that some factories will not operate this season. Climatic conditions have changed, however, since the estimate was made and although the rains will facilitate the lifting of roots, it remains to be seen what effect they will have on the growth and yield of the beets. The market for the first 3 weeks in October has been somewhat dull and there has been little fluctuation in prices.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:

	American Mid.	Egyptian F. G. F. Sakel.	Sea Island.		
			Good.	Extra fine.	Prices paid this Week.
20th Sept.	10.31	17.20	25.50	38.00	19.00-35.00
27th Sept.	10.20	16.50	25.50	38.00	27.00-35.00
4th Oct.	10.28	16.55	25.50	38.00	27.00-27.50
11th Oct.	10.28	15.65	25.50	38.00	11.03-30.50
15th Oct.	10.07	15.50	25 50	38.00	—
15th Nov. .... (local)	9.87	—	25.50	38.00	—

The market for American cotton was generally quiet during the earlier part of October, though there has been a further tendency for prices to decline in the absence of any particular supporting influence. The Bureau report produced a slight surprise in that the estimated crop was higher than that given in September. The quality of the crop, however, is believed to be distinctly poor, with unusually short staple in the Texas districts and lower grades in the Eastern States. Sea Island has been in fair request.

* * *

COCOA.—The Accra Crop is now in full swing and prices are lower with all other grades moving in sympathy.—(*By Courtesy of the Cocoa Planters' Association, Trinidad.*)

* * *

COFFEE.—On an average of all sales, states the *Times Trade and Engineering Supplement*, 19th October, coffee is about 10 per cent. cheaper than a year ago. Kenya has been selling at very modest prices of late. Prices per cwt. are as follows: Jamaica (Mount) 220*s.*, Costa Rica (Mid) 155*s.*, Kenya 105*s.*, Brazil 95*s.* A fine sample of Kenya Shortberry Mocha made 149*s.*

* * *

TEA.—Averages on the whole have remained low. Latest quotations according to the *Times Trade and Engineering Supplement*, 19th October, have been as follows: Ceylon 18.62*d.*, Northern India 14.8*d.*, Southern India 12.66*d.*, Java 10.06*d.*; Sumatra 11.73*d.*, Darjeeling 18.83*d.* and Assam 16.58*d.* Ceylon, Java and Sumatra are all thought to have had average yields in quantity, but China is known to have a short yield and is, indeed, importing.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:

	d.
3rd October	9½
11th October	9 15/16
17th October	9⅞
22nd October	9¾
29th October	9 3/16
2nd November	9½
15th November	8 5/16

During the first 3 weeks of October the Rubber market was somewhat more active, a sharp advance in price taking place on 8th October when the highest point was reached and 10 3/16*d.* was paid for Ribbed Smoked Sheet on the Spot. This advance was brought about chiefly by American buying, which, in turn, was caused by some Dutch proposals for co-operation with the British in holding a certain quantity of Rubber back from the market in order to bring about an improvement in values.

* * *

LIME PRODUCTS.—*Lime Oil.*—Handpressed is rather easier with sellers at 60*s.* per lb. *c.i.f.* Distilled is firm and unchanged with further business done at 30*s.* per lb. *c.i.f.*

Lime Juice.—Concentrated is neglected at present and the quotation is quite nominal. Raw is lower with sellers at 2*s.* 9*d.* per gallon *c.i.f.* for shipment. (*The West India Committee Circular*, 17th October.)

THE SUGAR INDUSTRY OF THE BRITISH WEST INDIES AND BRITISH GUIANA WITH SPECIAL REFERENCE TO TRINIDAD

THE SUGAR INDUSTRY OF THE BRITISH WEST INDIES AND BRITISH GUIANA WITH SPECIAL REFERENCE TO TRINIDAD.

BY

C. Y. SHEPHARD, B.Sc. (Econ.).

Professor of Economics, Imperial College of Tropical Agriculture, Trinidad.

THE sugar industry has ever been the shuttlecock of politics and its extent and localisation have been determined more by this factor than by economic considerations. The sugar industry of the British West Indies and British Guiana has by no means been immune from these political influences.

Historical Introduction.

Sugar production in these Colonies soon succeeded an original diversity of crops and, with its laborious processes, involved a rapid extension of the lucrative slave trade. With a monopoly of the English market, this industry proved extremely profitable and made the fortunes of many distinguished English families. The wealth of the planters was reflected in their extravagant modes of living, their "Great Houses," luxurious furniture, and costly plate. Absentee proprietors acquired an influence in the deliberations of Parliament which ensured the favourable consideration of their interests; indeed, it may be claimed that their activities were more profitable at Westminster than they could have been in the West Indies. In spite of minor setbacks the period was one of exceptional prosperity.

But this did not continue, and the nineteenth century records a dreary succession of political blows, the cumulative effect of which threatened the existence of the industry. The prohibition of the slave trade by the British in 1807, followed by the abolition of slavery in 1834, left the estates with a disorganised labour force which resulted in diminished production. (1) Even compensation amounting to £16,000,000 proved insufficient to readjust the industry to new conditions. (2) Finally the plantation owners' waning political power was shattered by the English Reform Bill of 1832.

(1) Sugar exports from Jamaica fell from 150,000 hogsheads in 1805 to 89,000 hogsheads in 1834 and to 30,000 hogsheads in 1865.

Pitman: *The Development of the British West Indies* p. 63. *Yale University Press.*

(2) The Commissioners estimated the value of the slaves at £34 million, and the capital valuation of the industry at £219 million.

Slavery was continued in the foreign West Indian Islands and Brazil, but British producers were assisted by a discriminating tariff levied against slave-grown sugar. In 1846 this differential duty was lowered and then abolished. Costs of production in the British Colonies had doubled after the abolition of slavery and, in the absence of a protective tariff, the position became precarious. (3)

The "plantocracies" in the islands and British Guiana endeavoured, with little success, to remedy the labour shortage by sporadic recruitments from Madeira, St. Helena, Sierra Leone, Malta, Germany and other places. In 1845, following the example of Mauritius, began that steady flow of indentured immigrants from India, which continued, almost without intermission, until 1917 when the Government of India terminated the system in response to national feeling. While the earlier methods of recruitment left much to be desired progressive amendments removed the worst abuses and subsequent enquiries revealed the system in a favourable light. Chinese labourers, who made excellent agriculturists were also recruited, but on the score of expense, and in view of the fact that they found more profitable scope for their aptitude in other spheres, the process was discontinued. (4) With indentured labour and other assistance, a moderate degree of prosperity was restored.

(3) In evidence before the Committee of Sugar and Coffee Plantations in 1848 it was stated that the cost of producing muscovado sugar in Antigua rose from 7*s.* 6*d.* per cwt. under slavery, to 16*s.* 6*d.* with free labour; in Barbados from 6*s.* to 15*s.* 6*d.* per cwt.; and in British Guiana to 25*s.* Costs of production in Cuba and Porto Rico during the latter period were estimated at 8*s.* and 8*s.* 6*d.* per cwt., respectively. Beet sugar was not at this time a serious competitor and is said to have cost 24*s.* 4*d.* per cwt. to produce.

(4) Chinese emigration was almost entirely male, tradition binding the women to the ancestral village. Between 1853 and 1913, 15,720 Chinese immigrants were introduced into British Guiana, of whom 13,485 were males and 2,235 females. In 1911 there remained 1,481 males and 1,141 females, the rapid decrease

Another factor was introduced when the rapid expansion of the beet sugar industry brought a threatening and formidable competitor into the field. Aided by protective tariffs and organised in cartels or trusts, the industry secured sufficiently high prices in the home markets to enable it, with the assistance of export bounties, to undersell cane sugar. Germany alone paid

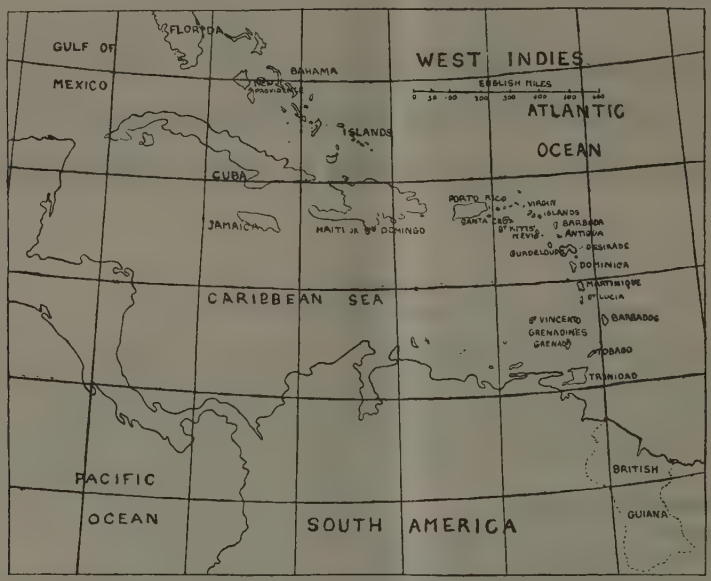


Figure 1.—*The Caribbean region, showing the principal British islands and British Guiana.*

$351,000,000 in sugar export bounties between 1840 and 1903. (5) The unprotected cane sugar industry of the British West Indies and British Guiana felt this competition severely during the seventies, and the position became acute during the eighties when many estates changed hands at greatly reduced valuations. Table I indicates the rapid relative rise of beet sugar production.

TABLE I.

WORLD PRODUCTION OF SUGAR. (6)

Period.	Average annual production in 1000's metric tons.	Percentage of Total.	
		Cane.	Beet.
1850-1851	1,507	90·6	9·4
1859-1860	2,127	79·5	20·5
1860-1870	2,323	71·4	28·6
1870-1880	3,357	58·6	41·4
1880-1890	5,242	47·8	52·2
1890-1900	8,296	41·2	58·8
1900-1910	12,578	42·4	57·6

being due to a readjustment of the sex ratio by male emigration. *See* Campbell, *Chinese Coolie Emigration*, King; and Clementi, *The Chinese in British Guiana*.

(5) It is claimed that the indirect benefits to agriculture more than compensated for this expenditure and for the higher price of sugar paid by the German consumers. $1 equal 4*s*. 2*d*. sterling; 1 cent equal ½*d*.

The situation was aggravated by the declining value of the sugar by-products, molasses and rum, caused by modifications in taste, the cheap price of sugar, and fiscal changes in Martinique and the United Kingdom. (7) Some relief was afforded by the abolition of slavery in Cuba in 1886, and the McKinley Tariff of 1890 by which the United States of America imposed a small discriminating duty against European subsidized beet sugar. Prices, however, continued to decline and British cane sugar was rapidly being ousted from the United Kingdom market by Continental beet sugar.

Table II shows that the price in 1896 was only half that of 1881.

TABLE II.

CANE SUGAR PRICES. (8)

YEAR.	PRICE IN SHILLINGS PER CWT.
1881	21·72
1884	16·41
1887	12·53
1890	13·33
1893	14·20
1896	10·85

(6) Excluding India throughout since estimates for this country are not available prior to 1898-99. Unless otherwise stated one ton equals 2,240lb.

(7) *E.g.*: the value of molasses and rum exported from St. Kitts-Nevis declined from £42,353 in 1882 to £8,903 in 1896. *W.I.R.C.* Report, p. 57.

(8) Unrefined sugar. Figures extracted from *W.I.R.C.* Report, App. C. Pt. 1, p. 196.

Table III indicates the decline in the United Kingdom's import of sugar from the British West Indies and British Guiana, and the rapid increase in the import of beet (chiefly refined) sugar.

TABLE III.

IMPORTS OF SUGAR INTO THE UNITED KINGDOM. (9)
(Quantities in 1,000's tons).

Year.	Cane Sugar.		Beet.		Total Beet and Cane.
	B.W.I. and B.G.	Total.	Refined.	Total.	
1882	198	732	133	398	1,130
1886	99	539	247	586	1,125
1891	54	376	540	1,001	1,377
1896	72	382	738	1,144	1,526

By the Dingley Tariff Bill of 1897 a duty, equal to the amount of the bounty, was imposed upon beet sugar with the result that the U.S.A. replaced the United Kingdom as the principal market for sugar from the British West Indies and British Guiana.

A serious outbreak of sugar-cane disease about 1890, which spread with amazing rapidity and intensity throughout the islands, threatened the very existence of the industry. Losses of cane, estimated at between 25 and 50 per cent. were reported from most of the islands during 1892-94, and later from British Guiana. It is believed that with the active interchange of cane varieties then taking place this disease, caused by *Colletotrichum falcatum*, was introduced from the East by a resistant variety. The Bourbon cane, then in general cultivation proved highly susceptible. (10) Immediate measures were taken to replace the Bourbon cane by White Transparent (or Caledonian Queen) and other more resistant varieties.

In the meantime a development of the greatest importance to the cane sugar industry was taking place in Barbados. In January, 1888, an overseer, Mr. I. B. Pilgrim, noticed some young seedling canes growing in a field adjacent to some experimental cane plots. (11) It had been thought that by long vegetative propagation the sugar-cane had lost the power of producing viable seed. Harrison (the late Sir John) and Bovell, immediately appreciating the commercial

(9) Figures extracted from *W. I. R. C.* App. C. Pt. 1, p. 195.

(10) *See* Nowell, *Diseases of Crop Plants in the Lesser Antilles*, pp. 297-301.

(11) The same re-discovery was made independently and almost simultaneously in Java where the matter was regarded as merely of academic interest until a serious outbreak of Sereh disease attacked the black Cheribon variety.

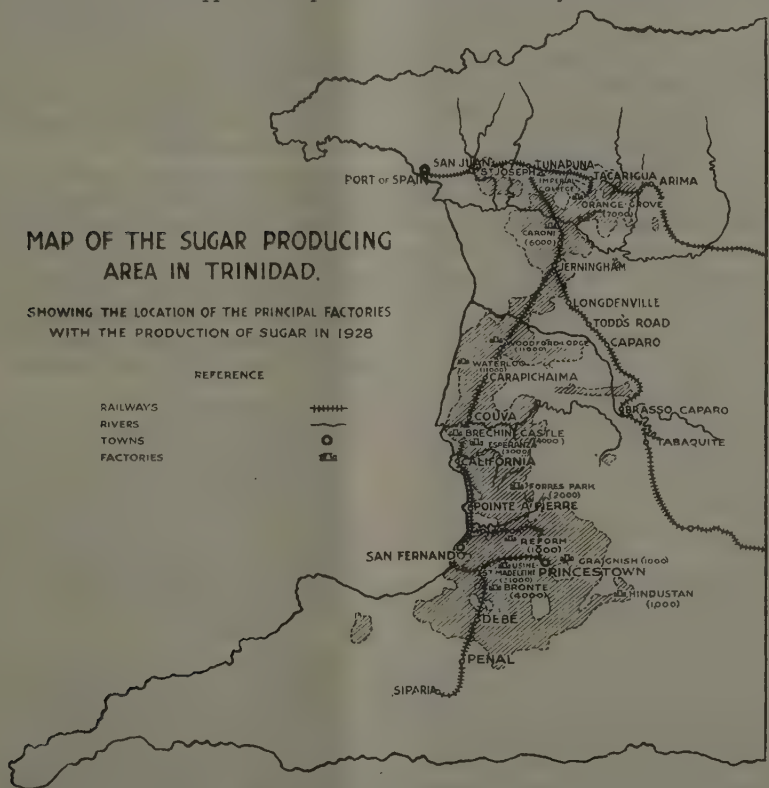


Figure 2.—The sugar production of Trinidad is localised along the western edge of the island, where climate and soil are most favourable.

importance of this discovery, vigorously prosecuted the production of seedling canes which were substituted for existing varieties immediately they gave sufficient agricultural promise. (12)

Planters reduced their costs by operating on a larger scale and introducing manufacturing refinements. A few scattered examples will indicate the widespread nature of this movement. In Trinidad, between 1889 and 1896, 88 factories were reduced to 39; (13) in British Guiana 230 in 1829 to 180 in 1849, and 64 in 1896; (14) and in Tobago 65 in 1862 to 38 in 1896. (15) Considerable sums were expended in modernising these factories and as many proprietors succumbed in the process their places were taken, in some cases, by Companies with wider financial resources.

For example the Colonial Company, between 1870 and 1895 spent £339,000 in improving its machinery and transport facilities in British Guiana and Trinidad, excluding the original cost of its Trinidad factory (£213,000). (16) British Guiana during 1880-1895 imported sugar machinery to the value of £1,307,500 (17) while the Government of St. Lucia loaned £40,000 between 1874 and 1877 for the modernisation of the Cul-de-Sac factories. One small Trinidad estate, Palmiste, between 1883 and 1894 spent £52,600 in reconstructing and modernising its factory and transport facilities. (18)

These improvements considerably lowered the cost of manufacture; for instance, those of the Colonial Company, Ltd., in British Guiana were reduced from £9 15*s*. per ton in 1883-4 to £4 15*s*. in 1895-96, and in Trinidad from £8 9*s*. 5*d*. in 1883, to £3 11*s*. 5*d*. in 1896. (19) Further economies resulted from these improved factories since they not only took a smaller quantity of cane to produce a ton of sugar, but also produced a grade of sugar realising £3 per ton more than Muscovado. (20)

However, in the cultivation of cane lack of scientific knowledge, and the absence of suitable mechanical power, precluded any similar economy. Wages, the principal item, were reduced by amounts varying from 10 to 25 per cent., and further temporary reductions were effected by allowing houses and other buildings to fall into serious disrepair (21) and by neglecting all save imperative operations. Despite these efforts many proprietors were forced to sell their estates at rapidly declining values, while in some islands estates were completely abandoned and allowed to revert to bush. (22)

In 1882 the exports of the British West Indies and British Guiana totalled £8,224,000, to which sugar contributed £6,884,000, or 84 per cent. By 1896, with the fall in the value of sugar, and notwithstanding the introduction of other crops and industries, the total exports had declined to £6,106,000 of which £3,251,000 or 53 per cent. was represented by sugar. (23)

By 1896 the industry was on the verge of collapse, and the situation became so critical that the Imperial Government appointed a Royal Commission of enquiry. The Commission, emphasising the vital importance of the sugar industry, recognised that the abolition of the bounty system would afford the greatest measure of relief. Perhaps the most important result of the Commission was the formation, at Imperial expense, of the Imperial Department of Agriculture, which so stimulated and coordinated scientific agricultural activity in the British West Indies, that it established a previously unknown feeling of confidence. The Department introduced more profitable alternative crops, and stimulated the reorganisation of the diminished sugar industry. (24) The Imperial Government subsidised the Colonial Governments when necessary by meeting the public deficits until 1912 when the improved economic condition removed such necessity.

The industry received a powerful impetus from the abolition of the Bounty System by the Brussels Convention in 1902. The Convention took effect as from 1st, September 1903 and the Imperial Government made a grant of £250,000 to assist these British Caribbean sugar producers during the interim. These indications of the revival of interest in the British West Indies and British Guiana by the Imperial Government

(12) Every known variety of cane is a highly complex hybrid the characters of which segregate and recombine in its seedling progeny in almost every conceivable variation. In rare cases these seedlings possess a better combination of characters than their parents *See Tropical Agriculture,* Sugar Supplement, Vol. IV, No. 9 p. 14, Trinidad.

(13) Lamont, Sir Norman, Bt. *Tropical Agriculture,* Vol. 5, No. 7, p. 167.

(14) *W. I. R. C.* Report, p. 83.

(15) *W. I. R. C.* Report, p. 107.

(16) *W. I. R. C* .App. C. Pt. 1, p. 178.

(17) *W. I. R. C.* Report, p. 28.

(18) Lamont, Sir Norman, Bt., *Tropical Agriculture,* Vol. V, No. 7, p. 167.

(19) *W. I. R. C.* Report, p. 84 and App. C., Pt. 1, p. 178 The term "cost of manufacture" is not defined so that comparison with present day figures is impossible, but these figures may be regarded as relatively correct.

(20) *W. I. R. C.* App. C., Pt. 1, p. 183. When vacuum pan sugar is made the molasses is inferior to that of the muscovado process

(21) *W. I. R. C.* Report, p. 54.

(22) In Barbados 547 sugar estates changed hands between 1851 and 1896. Between 1871-1880 and 1890-1896 the average price fell from £59 to £31 per acre (*W. I. R. C.* Report, p. 54). In St. Vincent a very large area of the best lands were in the hands of a few proprietors who had abandoned or were unable to cultivate a large proportion. The Government subsequently obtained possession of this land and divided it into small holdings. *W. I. R. C.* Report App. A, p. 121.

(23) *W. I. R. C.* Report, App. B, p. 157. Excluding Jamaica, whose sugar industry had already declined in importance, the figures for 1882 were, total exports £6,752,000; sugar £5,974,000 or 88 per cent. In 1896 again excluding Jamaica, and the gold industry of British Guiana, exports amounted to £3,945,000; sugar £2,951,000, or 75 per cent.

(24) In Tortola, Montserrat, Nevis, Dominica, Grenada and Tobago, sugar production, once the staple industry, is now negligible.

encouraged the sugar planters in Antigua, St. Kitts ([25]), and other Colonies to centralise their factories.

Unfortunately for British interests the Reciprocity Treaty of 1903 gave Cuba a monopoly of that portion of the U.S.A. market not catered for by her internal and insular production. This, coupled with the flow of American capital into the island resulted in such an amazing development (*see* Table IV) that the British producers in the Caribbean region were not only completely shut out of the U.S.A. market, but also had to face increasing competition in the unprotected market of the United Kingdom. ([26])

TABLE IV.

CUBAN SUGAR PRODUCTION.

Period.			*Amount in short tons.*
1899-1900	....	....	345,568
1902-1903	....	....	1,118,724
1912-1913	....	....	2,719,961
1922-1923	....	....	4,035,259
1924-1925	....	....	5,125,970

In 1898 Canada had voluntarily granted the British West Indies a preference of 25 per cent. of the raw sugar duty, increased to 33⅓ per cent. from 1st July, 1900, and to 37½ per cent. from 1st April, 1907. Before the abolition of the bounties and the granting of a preference to Cuba the British West Indies had found a more favourable market in the U.S.A. but from this period increasing supplies were diverted to Canada. A brief sketch will indicate subsequent relations with Canada. In 1912, by a ten years' reciprocal agreement, the British West Indies were granted an additional preference on raw sugar. ([27]) At the same time concessions granted to Canadian refiners in 1907 and 1909, which had diminished the preference, were repealed. By a second conference in 1920 the preference was increased to 84 cents per 100 lb. for sugar of 96°. ([28]) Again in 1925 the preference was increased to $1 for sugar of 96°. As a result the Canadian sugar market has been of increasing importance to the British West Indies and British Guiana.

When the Liberal Government came into power in 1906 it soon intimated that, while it did not desire to give bounties or to see their revival, it was contrary to its policy to impose countervailing duties or to prohibit the import of bounty sugars. Russia, the only important bounty-giving country outside the Convention, was conditionally persuaded to adhere to the Convention, while Great Britain was released from the Penal Clause, and in this way the danger to the Colonies of a revival of the bounty system was averted.

In 1912 the High Contracting Parties renewed the Convention until 1918, Great Britain withdrawing in 1913. In 1917 France notified withdrawal, and in 1918 Great Britain formally withdrew its pledge of 1902 not to give a tariff preference to Colonial sugar. By this action the Imperial Government was free to grant in 1919 a preference of one-sixth of the full duty to imported British sugar, increased in 1925 to one-third, and stabilised on the basis of £3 15*s*. per ton of sugar of 96° for a period of ten years. At the same time bounties, exceeding any ever given by Continental Governments, were conferred on home grown beet sugar. This small preference on British cane sugar has been the salvation of the sugar industry of the British West Indies and British Guiana, and its stabilisation for a period of ten years has provided a security which has encouraged improvements of a capital nature.

As Table V indicates, production diminished slowly but steadily until the outbreak of the war when the stimulus of high prices resulted in a rapid increase. Unfortunately the demands of the belligerents prevented the profits thus obtained from being utilised in improving the factory and other estate equipment, with the result that the properties depreciated, rather than appreciated, in real value. By the time normal supplies could be resumed the industry was involved in the slump of 1921. Increased scientific knowledge, aided by a stabilised preference, have encouraged the estates to begin a tedious and painful reorganisation with which they can face the future with a chastened and modest degree of hope.

TABLE V.

PRODUCTION OF SUGAR IN THE BRITISH WEST INDIES AND BRITISH GUIANA.

Period.			*Annual Average in tons.*
1902-05	....	....	249,000
1906-09	....	....	229,000
1910-13	....	....	198,000
1914-17	....	....	262,000
1918-21	....	....	227,000
1922-25	....	....	241,000

The Principal Characteristics of the B.W.I. sugar-producing islands and British Guiana.

The following brief accounts indicate the principal local characteristics of the more important sugar-producing islands and British Guiana, and illustrate the wide range of conditions under which cane can successfully be cultivated. At one time sugar formed the staple crop of all the islands but the depression during the nineteenth century compelled those which were unable to centralise their sugar production to a

(25) Gunthorpe's Central Factory, Antigua, planned in 1903, reaped its first crop in 1905. The St. Kitts (Basseterre) Factory was opened in 1912.

(26) Cuba now has to dispose of 1,500,000 to 2,000,000 tons of sugar outside the United States of America, the United Kingdom being her next best customer.

(27) *Cmd.* 6092.

(28) *Cmd.* 864. To protect the interest of Canadian refiners, the full duty, and the preference to a smaller extent, increases rapidly with higher degrees of polarisation. The polariscope scientifically determines the sucrose content of sugar. The "Dutch Standard" hitherto maintained by Canada, but regarded as an anachronism in sugar circles, consisted of a series of sugars ranging in colour from white to almost black, and numbered from 1 to 32.

sufficient degree, to resort to other crops. The diversification of crops now cultivated has thrown into relief those natural differences which were cloaked by the universal cultivation of sugar-cane.

JAMAICA :—Jamaica, the largest of the British West Indian Islands, with a population of 858,000, has an area of 4,450 square miles, the extreme length being 144 miles, and the greatest width 49 miles. The main divide trends from East to West with spurs running North-West and South-East, the latter culminating in the Blue Mountains with a maximun height of 7,388 feet. The surface is cut up into a complex series of ridges, with intervening gullies, liberally supplied with rivers, streams, and springs. Geologically the island exhibits considerable diversity, consisting of an igneous rock foundation overlaid with several distinct formations. The sugar industry is located mainly in the extensive alluvial flats of the parishes of Clarendon and St. Catherine, in the County of Middlesex ; in the alluvial deposits and marl beds of the parish of Westmoreland, and in the alluvial valleys of the Trelawney and Hanover in the County of Cornwall ; and, more recently, in St. Thomas in the East, in the County of Surrey. The average annual rainfall is 76 inches, varying from 105 inches in the North-East to 54 inches in the South. Production has risen rapidly from 14,000 tons pre-war, to 36,000 tons during 1920-24, with an estimate of 64,000 tons in 1926. Of 42 factories only one produces 8,000 tons and 26 less than 1,000 tons. The production of rum is a dominant characteristic of the industry. There is a tendency towards centralised sugar manufacture from canes grown by independent estates, though the configuration of the country is a handicap. Other and more profitable industries, particularly banana growing, have diverted capital and labour from sugar production.

ST. KITTS :—St. Kitts (or St. Christopher) has a population of 22,000 (1921 census), an area of 68 square miles, and is about 19 miles in length, with an average width of five miles except in the narrow South-East peninsular plain where the capital, Basseterre, with a population of 9,000, is located. The main range of rugged mountains, clothed in forest and tree ferns, runs North-West to South-East, culminating in the volcanic cone of Mt. Misery (3,711 feet), and conserves the rather deficient annual rainfall of 45 inches to 50 inches. From the low sea cliffs gentle slopes of detrital volcanic material rise to about 1,200 feet planted to a maximum height of 800 feet to 1,200 feet mainly in sugar-cane. The soil is light and deep, being particularly easy to work, but is susceptible to water shortage and rapidly loses fertility unless manured. The lower slopes are traversed by deep ravines, while most of the mountain water finds its way underground. Sugar remains the principal crop, the whole of the increasing output of nearly 20,000 tons being manufactured by the St. Kitts (Basseterre) Sugar Factory, Ltd., opened in 1912. Cane transport around the island has been rendered easy by road and estate railway. Yields average a little over 20 tons of cane per acre, while the sucrose content is high, and extraction efficient, an average of 8.58 tons of cane being required to produce one ton of sugar during 1925 and 1926. There is no extensive class of peasant cultivators.

Some seasonal labourers are recruited in the neighbouring island of Nevis where the coarse boulder formation of the lower slopes necessitates costly hand labour and results in low yields of cane, small quantities of which are shipped to St. Kitts.

ANTIGUA :—Antigua is irregularly oval in shape having an area of 108 square miles, and a population of 29,000. The steepness of the South-Western volcanic hills renders them unsuitable for cane cultivation. The highly calcareous soil of the North-East hills is usually sufficiently heavy to be fertile when well tilled and drained. The heavy clay soils of the Central Plain in some districts form excellent cane land when liberally manured and well drained, but the occurrence of salt patches renders some of the lands unsuitable for cane cultivation. The low annual rainfall of 45 inches is a serious factor but is partly offset by the retentiveness of the soil. The bulk of the island crop, which recently increased rapidly, is manufactured by the Gunthorpe's factory which in 1927 turned out a record of 19,000 tons of sugar. The estates contributing cane possess some financial interest in the factory. Yields of cane per acre are not high but both sucrose content and extraction are good, an average of 8.76 tons of cane producing one ton of sugar during 1926 and 1927. (29)

ST. LUCIA :—St. Lucia has an area of 233 square miles, with a maximum length of 24 miles, a maximum breadth of 12 miles, and a population of 56,700. The island is volcanic, the main ridge of mountains traversing the island from North to South at a height of 1,500 feet, with peaks exceeding 3,000 feet in the South-West part. Ridges from the central range provide narrow well sheltered valleys in which discontinuous areas, totalling 4,750 acres, are under sugar-cane. Four factories, each situated in a well-watered valley, produce a total of about 5,000 tons of sugar and a varying quantity of syrup or fancy molasses. There is at present a tendency to extend cane cultivation, by irrigation and by breaking up new lands. The introduction of new varieties of cane, and co-operation between the factories is likely to increase production and efficiency, but transport difficulties hinder expansion or further centralisation.

BARBADOS :—Barbados is a sugar-producing island of exceptional interest. With an area of only 166 square miles it supports a population of 156,000 or 940 to the square mile. The island is flat but rises by wide terraces to a maximum height of 1,100 feet. The surface rock consists

(29) This is nearly twice the yield of the old muscovado process.

of coral limestone except in the North-Eastern, or Scotland, district, where the underlying estuarine and oceanic beds of sandstone, clay and chert are exposed. In the porous limestone areas streams are absent or subterranean. The rainfall varies between 50 inches and 70 inches and the heavy retentive red and black clay loam soils require and receive frequent thorough cultivation and heavy applications of pen, imported sheep, and artificial, manures. Sugar remains the predominant product, the equivalent of about 70,000 tons being annually produced, of which a large, but variable, proportion is exported as syrup or fancy molasses to the North American market. Favoured by a healthy climate, fertile soil with good natural drainage, a large and comparatively energetic labouring population, and locally raised seedling canes of high sucrose content, the estate proprietors have maintained an intensive cultivation of the soil. Ratoons are the exception, cane being frequently rotated with food crops, such as yams, sweet potatoes, eddoes and maize, or fodder crops such as guinea corn and Imphee, or 'cash' crops such as cotton. Although favourable agricultural factors enabled planters to resist the trend towards centralisation of manufacture, the 440 factories of pre-war days have now been consolidated into about 250. There is a tendency for planters to maintain their agricultural independence and sell their canes to a convenient large factory except when a high price for syrup renders the operation of their own antiquated mills profitable. Further centralisation with greater security of supply to the factory appears inevitable. Cane yields are relatively high, sucrose content exceptionally good, but in some of the smaller factories extraction is low. The planters are partly financed by the Sugar Industry Bank. The Imperial Government granted £80,000 to enable the industry to tide over the depression, pending the abolition of the bounty system by the Brussels Convention. This sum was not distributed among the individual plantation owners, as intended, but was kept intact and used as the nucleus of a Sugar Industry Bank. The original sum now amounts to £180,000.

British Guiana:—British Guiana, on the mainland of South America, contrasts in many ways with the varied conditions of the islands. With a coast line of 250 miles, a maximum depth of 600 miles, and an area exceeding 90,000 square miles, she supports a population of only 298,000, of which nearly 40 per cent. are East Indians. The cultivated area of about 200 square miles is confined to the coastal alluvial flat, some ten miles in depth, and the banks of certain rivers for some distance inland. A considerable area of this coastal sugar belt is below spring tide level and has to be protected by elaborate and costly sea defences which, with canals and sluices, keep out salt water and drain, sometimes by pumping, accumulated fresh water during the wet season. The soils are stiff or plastic impermeable clays with varying percentages of silt underlaid by silt or sand. Locally termed 'pegasse' soils possess a distinct black surface layer up to 5 feet in depth formed by decomposed forest material or reeds and rushes. The soils are strongly acid in reaction. Drainage presents the most difficult problem, the land being divided by the main navigation canals some 20 feet wide, the main drains, and the elaborate system of subsidiary drains, which hamper mechanical tillage. The cane is drawn by animals or tractors along the navigation canals in scows or punts, each 50 feet long and 4 feet deep, holding 12 to 15 tons of cane. Cable drawn implements are operated from punts. Humus is deficient except in the best pegasse soils and among other remedies recourse is had to flooding temporarily abandoned fields. Plant canes give high yields and 3 to 5 ratoons are reaped. Exports of sugar during 1920-24 averaged 90,000 tons per annum, there being 39 factories in 1922 with a cultivated area of 61,000 acres. The crop is spread over two periods: February to June, and September to January. Shortage of labour hinders existing plantations and prevents rapid expansion. The Colony is famous for its "Demerara Crystals," which, originally a product of the Bourbon cane, are now produced to some extent in the islands, and, it is to be regretted, improperly imitated outside the West Indies by dyeing sugar produced by different processes.

Trinidad:—The main features of Trinidad have already been described in "Economic Geography." The cane belt lies along the western coast, the northern section the Caroni Plain, the central focussed around the town of Couva, and the southern in the undulating Naparima District (Figure 5). The rainfall averages about 65 inches per annum. For many years the canes have suffered severely from 'froghopper blight.' This damage has become so dominating a factor that it has necessitated and accelerated agricultural improvements. Yields are low, averaging 18 to 20 tons per acre on estates, but special stress is now being laid upon pen and artificial manuring, thorough cultivation, good drainage, and the use of leguminous plants to restore and maintain soil fertility. On the plains, animal and steam cable implements have long been utilised but in the Naparima District cultivation had to be performed almost entirely by hand labour until the recent introduction of powerful caterpillar tractors. The record 1928 crop of 80,000 tons was manufactured by 13 factories, to which one contributed nearly 31,000 tons, and four of the remaining factories over 35,000 tons, or, together more than 81 per cent. It is possible that within the next generation nearly the whole of the island crop will be produced by two factories. Two-fifths of the cane supply is grown by cane farmers who possess no financial stake in the factories but sell their cane on the basis of a sliding scale which varies with the price of sugar. East Indians, formerly introduced under a system of indentured Immigration, now constitute one-third of the total population. The wide diversity of

agricultural wealth, the flourishing oil and asphalt industries, and the need for more intensive cultivation is rendering the labour situation difficult and places a premium upon labour-saving devices.

Pests and Diseases. ([30])

In addition to the local factors described mention should be made of the more important pests and diseases which cause damage varying in incidence with geographical position, seasonal and cultural conditions.

Pests.

The moth borer (*Diatraea saccharalis*, Fabr.) is a serious pest, severe injury resulting from the tunnelling of the larvae in the cane stem. Infestation is diminished by treating planting material with Bordeaux mixture, and destroying attacked shoots, caterpillars, and eggs. It is attacked by parasitic insects of which the most important is *Trichogramma minutum*.

The larger moth borer (*Castnia licus*, Drury) occurs only in British Guiana and Trinidad, where it is responsible for extensive losses of cane. No satisfactory method of control has been evolved but the intensity of attack is diminished by catching the moths, flooding the land, collecting the larvae from the cane, and encouraging insectivorous birds.

Froghoppers occur in British Guiana but cause little damage. In Trinidad *Tomaspis saccharina*, Dist., has become so important that a special Committee of investigation has been appointed. The damage is caused by the sucking action of the adult insect on the cane leaves and may vary between a slight check in growth and complete destruction of the cane. Hardy and Turner ([31]) have shown that the intensity of the damage is closely associated with soil conditions and that those soils bearing 'blighted' cane are so markedly acidic and so deficient in exchangeable calcium that a material improvement in their lime status appears to be a necessary preliminary to their amelioration.

Other insects have attracted attention but are not of great economic significance; some are merely scavengers and attack only already injured or diseased cane.

Diseases.

The most important fungal disease—known as root disease—results in a stunted condition of the stool, and research has indicated that wet weather, poor soil, defective aeration, and insect injuries, are predisposing factors. Thorough cultivation and rotation of crops form the greatest safeguards.

Mosaic, a virus disease, causes losses under a wide variety of conditions, which may extend to the complete destruction of the crop. Clearing the land of infected material, planting resistant varieties such as Uba, and crop rotation, form effective measures of control. Gumming disease, caused by *Bacterium vascularum* (Cobb) E.F.S. occurs in St. Lucia and St. Kitts but can be controlled, particularly by efficient drainage.

Other diseases exist but, since they are subject to effective control, or only affect canes already damaged, are not sufficiently important to warrant consideration.

The Ste. Madeleine Sugar Co., Ltd., Trinidad.

Conditions vary so much from country to country, and even within a country, that the following description of the Ste. Madeleine Sugar Co., situated in the Naparima District, (Figure 10) should indicate better the strenuous efforts that are being made to overcome the present depression than a more generalised account.

Much of the area owned by the present company has been under cane cultivation for over a century without rotation of crops, there being at one time about 100 separate factories. With increasing financial distress the private estates were gradually amalgamated by companies into the existing organisation. Of the 24,500 acres owned by the Company, 11,500 are under estate cultivation, 6,000 are rented to cane farmers, 5,700 are uncultivated, and the remainder consists of pastures and traces. Cane is also received from a considerable area not owned by the Company. The Company maintains 80 miles of standard gauge (4 feet 8½ inches) and 10 miles of 2 feet 6 inches gauge railway, and a network of roads and traces which are supplemented by the Trinidad Government Railway and the public roads and traces.

The Company is endeavouring to reduce its costs of production (Figure 11) by increasing its sugar production, introducing labour-saving devices, and ameliorating soil conditions.

The increased production of sugar (*see* Table VI) and increased efficiency in machinery have resulted in a considerable reduction in manufacturing costs. While most of this increase in crop is due to the acquisition of additional estates, part is the result of a more intensive use of the land. The estate plants 2,000 to 3,000 acres annually, principally between August and November, during the wet season. The canes are reaped some 15 to 18 months later, and then cut annually as ratoons for a variable period. On account of the laborious process of planting,

(30) *See* Ballou: *Insect Pests of the Lesser Antilles* and *Insect Pests of Sugar-Cane in Antigua and St. Kitts*; and Nowell: *Diseases of Crop Plants in the Lesser Antilles*.

(31) See *Minutes and Proceedings of the Froghopper Committee* and the *Journal of Agricultural Science*, Vol. I, 1929 (Turner).

Figure 3.—A windmill sugar factory, Barbados, now abandoned. Each small estate formerly had its own factory. Note the method of transporting cane to the factory.

Figure 4.—A muscovado factory, Antigua, illustrating another stage in the evolution of modern sugar manufacture. Note the hand fed carrier which conveys canes to the mill.

Figure 5.—A portion of a modern sugar factory, Trinidad, capable of manufacturing over 30,000 tons of sugar in a season of about 100 crushing days. Central factories represent a heavy capital investment.

Figure 6.—Cane cutters and loaders, Antigua. The cane carts are drawn by mules or oxen. (Courtesy of Imperial Institute.)

Figure 7.—A train load of canes proceeding to the factory, Antigua. (Courtesy of Imperial Institute.)

Figure 8.—Raking canes mechanically from the railway truck to the cane carrier. A continuous and even flow of cane must be maintained.

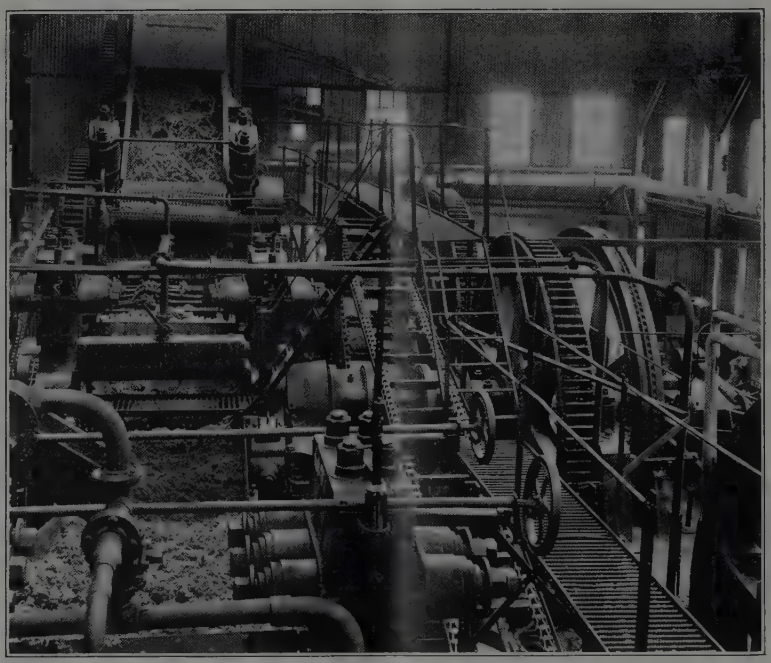


Figure 9.—Portion of Gunthorpe's Factory, Antigua, showing cane passing through the mill. (Courtesy of Imperial Institute.)

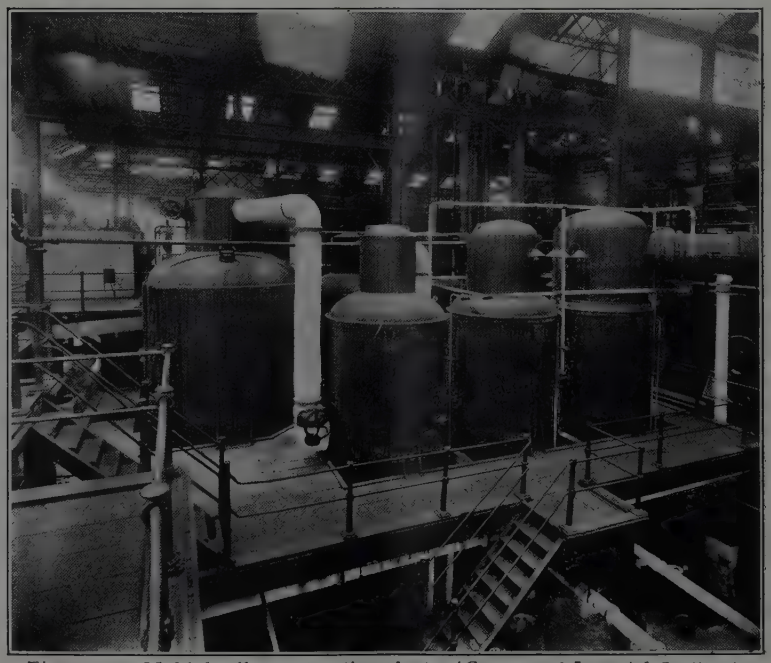


Figure 13.—Multiple effect evaporating plant. (Courtesy of Imperial Institute).

plant canes, in spite of heavier yields, (*see* Table VII), cost more per ton to produce than ratoons.

TABLE VI.

STE. MADELEINE SUGAR COMPANY'S PRODUCTION.

Year.	Crop.	Year.	Crop.
	In tons of sugar.		In tons of sugar.
1875	2,658	1915	17,067
1885	4,876	1925	23,520
1895	9,346	1928	30,939
1905 (32)	8,711		

TABLE VII.

YIELD OF PLANT AND RATOON CANES.

In tons per acre.

Year.	Plants.	1st Ratoons	2nd Ratoons	3rd Ratoons	4th Ratoons
1925	24·19	18·58	13·94	13·33	12·05
1926	28·32	19·60	15·11	13·89	13·75

In selecting varieties special attention is given to their ratooning powers. (33) Many new varieties are constantly being tested and, as they demonstrate their superiority, are used to replace the standard canes which, for reasons requiring further investigation, tend, after a time, to deteriorate. D. 625 and B. 156 have given way to B.H. 10(12) and Uba, the latter possessing exceptional ratooning powers. As excessively ratooned canes are particularly susceptible to froghopper blight and other damage, and tend to increase in cost (Table VIII) it has become the policy to replant after the second ratoon (Table IX) except in the case of Uba.

TABLE VIII.

LABOUR COSTS ONLY OF PLANTING, CULTIVATING, REAPING, CARTING AND LOADING INTO RAILWAY TRUCKS, OF PLANT AND RATOON CANES IN DOLLARS PER TON.

Plant.	Ratoons.				
	1st.	2nd.	3rd.	4th.	Other
3·2	1·47	1·53	1·55	1·40	1·67

(32) This crop was below the average.

(33) Thus B. 6032, a good plant cane, ratoons badly and is therefore being discarded. Several canes with excellent records in Java have been introduced but as in that country they are grown only as plant canes it is doubtful whether they will ratoon well. Cane seedlings have their country of origin indicated by letters and an index number. Thus B., Ba., and B.H. stand for Barbados, D. for Demerara, P.O.J. for Java, S.C. for St. Croix, &c.

TABLE IX.

PLANT AND RATOON CANES.

Average acreage division during 1925 and 1926.

	Acres.	Percentage of total area.
Plants reaped	2,622	35·0
1st Ratoons	2,615	35·0
2nd Ratoons	1,459	19·3
3rd Ratoons	395	5·3
Remaining Ratoons and Standovers	407	5·4
Total	7,498	100·0

The increase in the crop requires additional labour and land. Prior to 1917 labourers, who were indentured to estates for five years, were brought from India, each estate indenting for the number required. Since the cessation of indentured immigration many Indians have been repatriated (34) while the growth of the sugar and other agricultural industries, the development of the oil and asphalt industries, and the expansion of motor traffic and road work, have intensified the demand for the remaining labour force. The Company has endeavoured to induce labour to remain by laying out house lots, and providing facilities for the cultivation of cane by peasants, who are known as cane farmers New areas have been opened up, labour-saving methods and devices introduced, and railway facilities for the delivery of farmers' cane established in areas not owned by the Company. Nearly 40 per cent. of the cane crushed by the factory is now supplied by farmers. The latest development lies in the Oropouche Valley, an area of some 10,000 acres, where, owing to lack of transport facilities, peasant proprietors have hitherto eked out a miserable existence by growing food crops, particularly rice, and small patches of indifferent 'cash' crops. With estate railway facilities this area will provide an increasing quantity of cane without seriously interfering with the existing estate labour supply. Since the farmers possess inadequate capital the Company advances money, through its Agricultural Credit Societies, which is recovered when payment is made for canes. When, in 1920, sugar reached an unprecedented high level (35) the various sugar estates, in their anxiety to secure additional cane, advanced money recklessly and established purchasing scales in their neighbours' territory. Many farmers received advances from more than one estate. With the slump in the price of sugar, and therefore of cane, in 1921 (*see* Figure 12) many of these advances became irrecoverable

(34) 9,111 East Indians were repatriated between 1920 and 1927. The total agricultural population is about 96,000.

(35) On 19th May, 1920, 96° sugar, f.o.b. Cuba, sold at £101 18*s.* 4*d.* per ton and fell on 28th December, 1921 to £7 14*s.* 0*d.* per ton.

and heavy losses were incurred. Many farmers gave up cultivation and the supply of cane was nearly halved. To avoid wasteful competition, eliminate unnecessary haulage, and facilitate the recovery of advances, the sugar estates agreed, in 1922, to restrict the purchase of cane by each factory within defined areas, and to adopt the same sliding scale of payment. To encourage farmers the Company has established an understood, though not guaranteed, minimum price of $2.88 per ton of cane, and has improved the conditions of land tenure. Uba, which ratoons exceptionally well, and smothers weeds by its dense growth, has reduced labour requirements, and the rapid expansion in the Ste. Madeleine Sugar Co.'s crop during the past five years is largely due to the extended use of this variety. The heavy nature of the soils prevented cattle ploughing and the undulating land prohibited the use of steam cable ploughs, so that preparation for planting had to be accomplished in the wet season with hand labour. The recent introduction of 60 H.P. caterpillar (36) tractors each drawing a four-furrow plough furnished with 28-inch discs, or with chisels or knives, has enabled considerable preparation for planting to take place in the dry season (Table X). With additional equipment it is anticipated that all land to be replanted will be ploughed or chiselled (37), made into beds and formed, and perhaps drilled (38), by mechanical means thus effecting a very considerable saving in hand labour. The present equipment consists of four 5-ton, one 10-ton, and three 60 H.P. tractors, four Holt and one La Crosse ploughs, two Killifer subsoilers, two Killifer chisels, three road graders (also used for bed formation) one Killifer cultivator, and one harrow. (39) (figure 13.)

TABLE X.

WORK DONE BY TRACTORS

Dry Season, 1928.(40)

Acres.		
1,372	....	ploughed
570	....	graded or round ridged.
190	....	unploughed fields chiselled.
131	....	unploughed fields chiselled a second time.
136	....	chiselled after ploughing.
21	....	drilled.
Miles.		
38		roads and traces graded.

It has been the practice in the past to allow fields whose fertility showed signs of exhaustion to revert to bush for a number of years. With adequate land this method was very suitable, but it is clear that with increasing crops fuller use will have to be made of the land. The Company is attempting to maintain the fertility of the soil for longer periods, to evolve a quicker method of restoring fertility, and to discover varieties of cane tolerant to poor conditions.

Great stress is laid upon the value of pen manure, and it is the practice to apply 20 tons per acre shortly before or after planting. When not working, all animals are kept in covered or open pens containing a layer of cane trash, grass, megass, (41) or other vegetable matter, into which is trampled the animal excreta and urine. Additional material is added until at the end of the dry season the pens are 4 feet to 5 feet deep in manure. Some 26,000 to 28,000 tons of manure are produced by this method, but as this is insufficient to meet the requirements of plant canes alone, supplementary sources have to be developed. Trials are being made with methods of producing artificial farmyard manure, and with an efficient and economical method, a very considerable expansion of manuring will take place. Indifferent results have been obtained with artificial manures, and elaborate experiments under statistical control are now being prosecuted. The degree of acidity and the lime status of the greater part of the Company's soils have recently been shown to be closely correlated with the intensity of froghopper blight. Since the amount of lime required to correct this undesirable acid condition would be large (frequently more than 20 tons per acre) the cost involved is regarded as entirely prohibitive. (42) Experiments are nevertheless being made to test the effect of smaller applications on areas where lime deficiency is of lesser magnitude.

Extensive trials are being made with green dressings as a means of soil amelioration. It is now the invariable practice to plant the cane banks with Sword Bean (*Canavalia ensiformis*),

(36) The numerous drains and ravines, necessitated by extreme heaviness of the soil, involve the use of caterpillar tracks.

(37) The ploughs will not throw a furrow uphill so recourse is had to chiselling where no double slope is available.

(38) Drains are normally 25 feet apart and the drills are made, usually five feet apart, across the beds to carry off surplus water. Mechanical drilling across the bed would destroy the camber, and the drains. Mechanical drilling along the bed would interfere with drainage. A compromise is therefore being tried, the centre being mechanically drilled along, and the sides hand drilled across, the bed.

(39) The tractors consumed 30,000 gallons of gasolene at 40 cents a gallon, the tax on which amounted to $3,600. It is hoped to introduce tractors using crude oil, which at about 10 cents per gallon would represent a very considerable saving. At present the weight of tractors using crude oil is a severe handicap.

(40) During 1924, the first year, 40 acres only were ploughed. One tractor will plough four to five acres a day, and, where the contour of the land prevents ploughing, chisel or knife seven acres a day.

(41) Cutting up the vegetable matter hastens decomposition. Since there is inadequate labour to handle the manure this is not done during the dry season. Enormous quantities of vegetable matter are necessary, and, to save labour, mechanical grass cutters have been introduced. To save cartage, open pens for bison are established in the fields to be manured, but in Trinidad other animals, *e.g.*, Zebus and mules are too susceptible to climatic conditions.

(42) Ground limestone delivered to estate costs about $5 per ton. Land can be purchased for $25 to $50 an acre.

Sunn Hemp (*Crotalaria junces*), or Woolly Pyrol (*Phaseolus mungo*), usually an early and a late-maturing variety on alternative banks, which are turned into the soil as the banks are required for moulding (or earthing up) the cane. Fields that have been ploughed, but are not required for planting for periods up to three months, are broadcasted with Sunn Hemp or Woolly Pyrol, to provide a quick cover for keeping down weeds and preventing wash. The cover crop is turned in at cane planting.

To restore the fertility of fields more quickly, it is proposed to plant abandoned fields in *Tephrosia candida*, Pigeon peas *Cajanus indicus*(43) or Bengal Beans (*Stizolobium* sp.) (44) but, as ploughing is necessary, this method cannot become general practice until additional equipment is available.

Fortunately Uba is more tolerant than seedlings to poor soils, and this variety has therefore been extended to all soils on which seedling canes could not profitably be cultivated. (45) Unfortunately Uba does not shed its trash and has to be burnt before reaping, thus destroying humus and useful (and harmful) parasites. (46) It is of low sucrose and undesirably high fibre content, and is troublesome in the factory. But for these disadvantages the cultivation of Uba would have been extended even more rapidly.

(43) Pigeon Peas are a popular local food and suffer from praedial larceny.

(44) Bengal Beans provide forage and beans suitable for stock.

(45) This should be borne in mind in comparing yields and costs of Uba and seedlings.

(46) This may account for the increasing prevalence of the moth borer.

These measures also form part of the comprehensive scheme for froghopper control. Among other methods, recourse is had to insecticides, the most suitable of which is at present Cyanogas (Calcium Cyanide powder) which is effective under favourable conditions and is dusted on the cane stools immediately the presence of froghopper nymphs is reported.(47) Greater stress is, however, laid on soil amelioration and improved agricultural methods.

While these measures are tending to reduce labour demands, there still remains a shortage during the crop season. Since transport difficulties limit the crop to about 100 days (48) during the dry season, which lasts from about the end of January to the beginning of June, all other considerations have to be subordinated to the daily delivery of 2,500 to 3,000 tons of cane to the factory. The two mills work day and night, except when out of cane, stopping only from Saturday afternoon to Sunday afternoon to effect the necessary cleaning, repairs, and adjustments. Factory costs increase rapidly with diminished deliveries of cane (Figure 14). As 44 per cent. of the 5,000 to 6,000 farmers produce less than 5 tons, and 80 per cent. less than 20 tons, per annum, evenness of supply to the factory is extremely difficult to maintain. At the beginning of the season it is impossible to ascertain whether the farmers' canes are ripe

(47) The cost of Cyanogas and its application average about $6 per acre.

(48) In South Africa the crop season extends over seven or eight months. Hence in Trinidad a factory must be twice the size to deal with the same crop. The cost of a factory in Trinidad is about £20 to £25 for every ton of sugar produced.

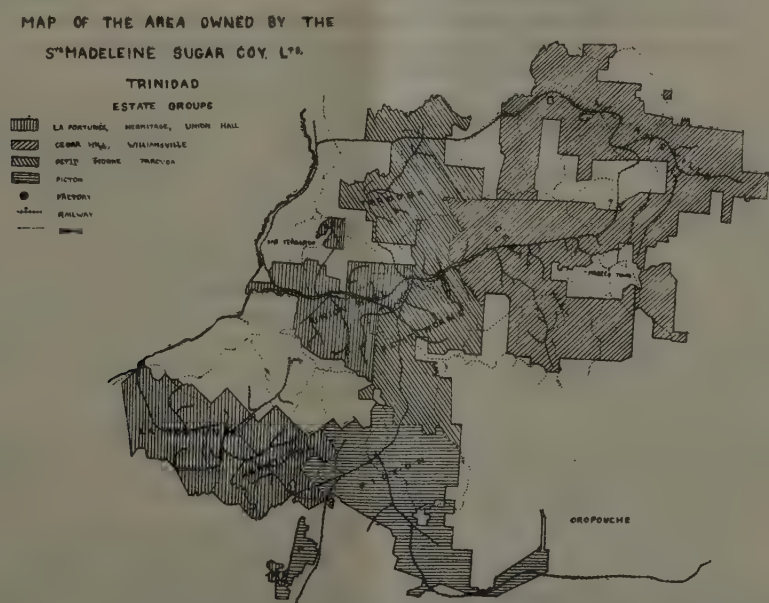


Figure 10.—The Ste. Madeleine Sugar Company has a large estate, 24,500 acres, situated in the Naparima District, where every effort is being made to overcome the depression in the sugar market.

and many farm areas are inaccessible until the dry season is well advanced. To surmount this difficulty, the Company during recent years has adopted the practice of supplementing the estate animal transport by hiring farmers' carts. As the season advances and the farmers' canes become ripe, and transport easier, the farmers use their carts for their own canes. (See Figures 15 and 16.)

In addition to the difficulties experienced in regulating the daily supply, ensuring a good quality, avoiding loss in the weighing and transit of cane, and recovering advances, &c., small farmers do not regularly replant a portion of their land. Since their responsibilities are small, they can, with little loss, give up cane growing during a depression and so cause wide variations in annual supply (*see* Table XI). Badly cultivated patches of cane constitute a reservoir of diseases and pests. To encourage larger farmers, the Company offers better terms of payment. These contracting farmers, who now number 31, supplied nearly 30,000 tons of cane in 1928. If each farmer averaged 50 tons of cane per annum, the Company's cane farmers could be reduced to 1,500 who might, through their Agricultural Credit Societies, be co-operatively organised for the delivery of cane.

The estate traces are mere earth tracks which become impassable during wet weather. (49) The Company now employs grading machines (50) that give a camber which helps to drain the traces and maintain the surface. Thirty-eight miles were dealt with in 1928.

(49) In the exceptionally wet "dry" season of 1927 no less than 30,000 tons of cane remained unreaped owing to the impassable condition of the traces.

(50) As mentioned above these machines have proved very effective in round-ridging cane beds.

For carting, and providing manure, the Company maintains over 2,000 head of stock. (Table XII.) Among mules 35 per cent. of the available working days were lost for various reasons. Of the days worked less than 30 per cent. were utilised for carting canes. (Table XIII.) Animals are therefore expensive as a means of haulage. Experiments are being made with tractors, the main difficulty being to find a suitable type of cane cart. It is anticipated that since each tractor will haul a fleet of carts, and cartage will be less dependent upon weather conditions, a considerable amount of labour will be freed for other urgent requirements. (51) But for the difficulty of securing an adequate supply of pen manure, this would enable many head of cattle and mules to be dispensed with. To supplement the synthetic methods previously mentioned, the Company has centralised its dairy cattle, and, with expansion, it is anticipated that the sale of milk and milk products (52) will cover all the dairy expenses and thus a considerable quantity of manure will be supplied free of cost.

The Company, like all other cane sugar producers, is on the look-out for a cane harvester (53) that will not only cut, but also top, the cane mechanically.

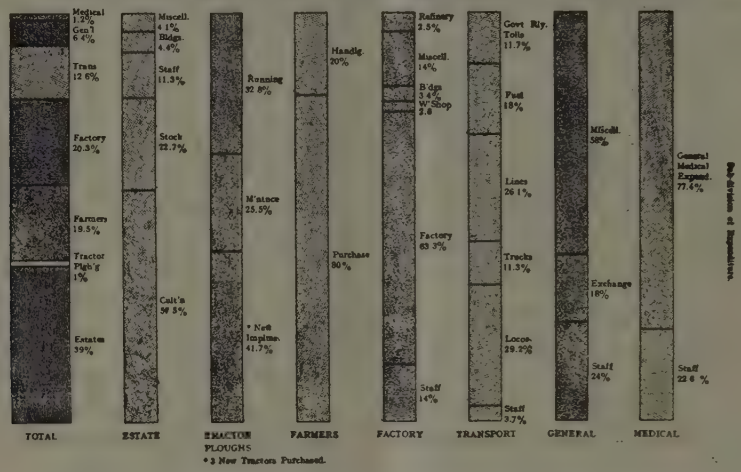
(51) Owing to the increasing difficulty of obtaining carters many youths unsuited to the work are employed. The tractors will afford an outlet for the preference for mechanical work shown by West Indians who dislike field work.

(52) In 1927 Trinidad imported condensed milk to the value of £100,495 and milk products or their substitutes to the value of £109,365, *C.P.* 68, 1928.

(53) Each cutter averages 2 65 tons per day. Hence an average of more than 1,000 men are required daily merely to reap cane for the factory, and a similar number for carting.

STE. MADELEINE SUGAR COMPANY, LTD.

PERCENTAGE DISTRIBUTION OF TOTAL DEPARTMENTAL EXPENDITURE.



THE TOTAL ANNUAL LOCAL EXPENDITURE AVERAGES $1¾ MILLION PER ANNUM.

Figure 11.—The costs of production of sugar by the Ste. Madeleine Sugar Company are graphically presented by this chart.

TABLE XI.

TRINIDAD CANE-FARMING AND SUGAR CROP RETURNS.

Period.	Island.					Ste. Madeleine Sugar Company.					
	Sugar produced tons.	Tons crushed.		Cane-farmers.		Sugar produced tons.	Tons crushed.		Price per ton of cane $	Cane-farmers	
		Estate.	Farmers.	East Indian.	West Indian.		Estate.	Farmers.		E.I.	W.I.
1898-1902	56,287	292,515	134,651	3,261	4,174	....	99,653	21,226	....	653	812
1903-1907	50,060	347,711	178,192	5,439	5,162	13,461	90,730	41,662	....	1,587	1,172
1908-1912	48,302	393,805	157,590	6,409	5,839	13,153	120,274	35,612	....	1,872	1,233
1913-1917	58,365	397,215	282,404	9,933	7,008	17,606	124,875	56,692	....	3,063	1,400
1918	45,256	252,783	266,144	12,158	8,244	16,643	95,442	80,388	3.84	4,712	2,332
1919	47,850	275,451	270,324	12,370	8,568	16,482	95,570	72,551	4.74	4,322	2,292
1920	58,416	319,421	344,226	14,536	10,824	17,510	93,494	86,344	8.40	4,393	2,778
1921	54,933	286,974	389,399	15,046	11,379	17,740	84,232	106,367	4.84	5,132	3,643
1922	59,948	340,358	355,364	12,605	8,745	17,880	76,334	95,551	2.57	4,072	2,651
1923	41,619	253,211	186,445	9,670	6,830	13,732	74,891	53,938	4.90	3,077	1,952
1924	52,045	324,361	237,298	9,952	7,116	17,203	109,336	59,792	4.52	2,965	1,835
1925	69,629	395,105	327,614	11,508	7,966	23,520	141,825	83,045	2.88	3,455	2,188
1926	73,561	384,002	358,879	13,492	9,447	29,365	162,358	111,316	2.88	3,862	2,822
1927	51,982	330,391	286,700	11,858	7,527	19,434	134,940	78,135	3.45	3,390	1,814
1928	81,551	449,634	375,162	13,224	7,444	30,939	176,691	113,020	2.97	4,712	2,174

With these measures fully developed, labour will be rendered available (Table XIV) for the cultivation of young plant and ratoon canes which at present have to be neglected during crop. The crop season is the main planting season for the cane farmers, partly because planting material can be obtained very cheaply (54) and partly because the farmer prefers a twelve month growing period. To relieve the crop pressure, the estate provides cheap planting material during the wet season, but little advantage is taken of this facility.

(54) The top joints of the cane only are used during the dry season because they give a better 'spring' and are useless for sugar production.

Unfortunately, part of the crop season coincides with the East Indian marriage season, and, since the guests are numerous, particularly in times of prosperity, temporary dislocation of estate work sometimes results. The rice planting and reaping seasons, and the competition of

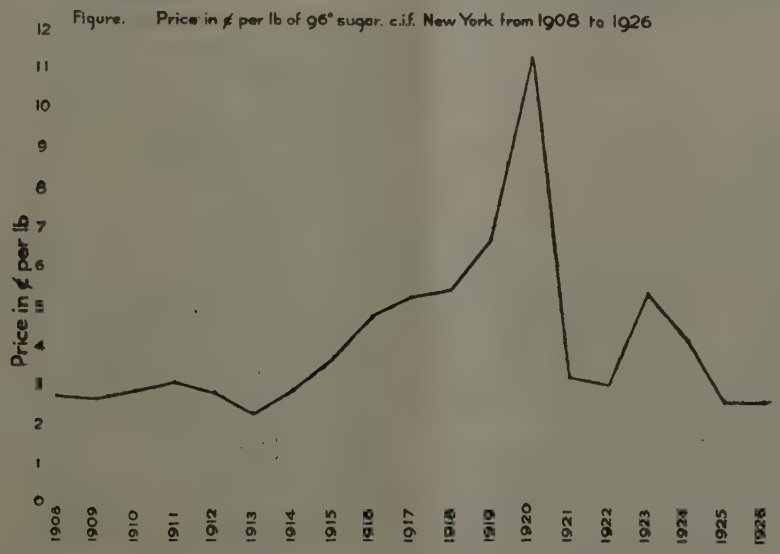


Figure 12.—Note the rapid rise in price during the war, followed by the post-war boom when sugar rose to an exceptionally high level. The sudden fall in 1921 brought disaster to many sugar producers, and the industry is still attempting to adjust itself to the new level of prices, which approximates to that of the pre-war period though costs of labour and materials are still high.

cane farmers at certain periods of the year, also interfere with estate routine, though on account of the higher pressure of work any interference during the crop season is more serious.

TABLE XII.

UNITS OF LIVE STOCK.
30th June, 1926.

Horses	78
Mules	580
Oxen	322
Cows	422
Calves	351
Steers	138
Heifers	162
Bulls	36
Others	89
Total	2,178

Labour-saving devices have reduced the factory labour demands to such small relative dimensions that although the numbers fluctuate greatly (Figure 17) they have little effect on the general labour situation. Owing to the seasonal variation in employment, some difficulty is experienced in retaining suitably qualified mechanics.

TABLE XIII.

DISTRIBUTION OF MULE AND OXEN UNITS, 1925-26.

	Mule units. Percentage Distribution.	Oxen units. Percentage Distribution.
Lost	35·4	54·6
Implemental tillage	1·4	1·9
Working derricks	2·4	—
Carting canes	17·9	5·7
Carting forage	12·0	13·0
Carting bedding	10·1	14·9
Carting manure	7·3	6·7
Miscellaneous Cartage, &c.	13·5	3·2
Total Possible Units*	164,000	96,500

* Calculated on the basis of five days per week for 50 weeks equals 250 days per annum.

A problem of great importance is the profitable disposal of factory by-products, particularly molasses and megass. At one time a rum distillery played an important part in the economy of a cane sugar factory, but taxation and 'prohibition' have rendered returns from this source negligible. The profitable use of molasses for power alcohol, cattle food, fertilizer, &c., is being investigated. Megass is used primarily as fuel, and not only meets the normal requirements of a modern factory, but also produces a large surplus. Attempts are being made to utilise it profitably as fibre board or paper pulp.

Lack of deep water facilities at Port-of-Spain, and the additional handling necessitated by lighterage increase the cost of exporting sugar. A small tax is imposed upon sugar exports to meet the cost of repatriating East Indians who have served a term of indenture.

This brief and superficial description does not pretend to detail all the problems of all cane sugar producers, or even those of Trinidad. Some of the differences in other parts of Trinidad have already been noted, while many more might be enumerated. In the Caroni Plain, for example, small scale experiments indicate that irrigation might enable conditions to be produced artificially which would diminish froghopper blight and reduce costs of production. The political future of sugar is so obscure that it is doubtful whether the necessary capital would be forthcoming. Every estate has its own peculiar problems but it is hoped that the above account has served its purpose of indicating the manner in which the present situation is being faced.

TABLE XIV.

PERCENTAGE DIVISION OF ESTATE LABOUR UNITS.

Subsoiling	*6·5
Round Ridging	*3·1
Draining	5·8
*Drilling, planting and supplying	9·1
Weeding	24·9
Digging Para grass	3·8
Clearing Pastures and Traces	*2·1
Making and applying manure	13·7
Destroying Froghoppers	4·2
Stripping and cutting canes	7·5
Heading, packing and loading canes, and working derricks	7·8
Carting canes	*7·4
Other operations	4·1
1,047,896 units	= 100·0%

* These operations can either be performed to a large extent, or be substituted by mechanical methods. This would tend to reduce the number of units employed in other operations, *e.g.*: weeding, which accounts for a very large percentage of the total labour units. It takes approximately five men-days to produce, reap and deliver to the railway trucks one ton of cane.

The Colonies in Relation to the World's Sugar Industry.

Attempts to compare the efficiency of sugar production in various countries are apt to be extremely misleading since conditions differ so fundamentally. The fact that yields of cane in Java and the Hawaiian Islands average more than 45 short tons per acre, whereas in Queensland, Mauritius, the Philippines, South Africa, and other areas, the average production is less than 20 short tons per acre, does not necessarily indicate inefficiency in the latter countries. That the high yields of Java and the Hawaiian Islands are due principally to irrigation is illustrated by the fact that, the yields per acre on estates in the Island of Hawaii dependent upon rainfall, averaged only 55 per cent. of those on irrigated estates in the Islands of Oahu and Main, during the period 1907 to 1921. (55) Even in comparing Java and Hawaii several important differences should be noted. In the former country, plant canes only, maturing in 11 to 15 months, are grown, and cane is rotated with food crops, particularly rice. In Hawaii the growing period is 18 to 24 months and ratooning

(55) See Report of the Experimental Station, H.S.P.A., 1922. In Java more than 90 per cent., and in the Hawaiian Islands more than 50 per cent. of the area under sugar cane is irrigated.

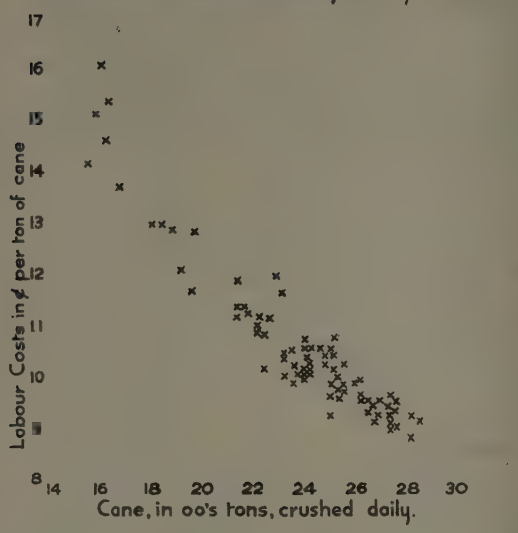


Figure 14.—The above diagram indicates that as the quantity of cane crushed increases, factory labour expenses decrease. Saturdays and Sundays, when crushing is not continued throughout the 24 hours, have been omitted. Oil fuel has been omitted from costs since its consumption is largely independent of the rate of crushing. The following table shows some of the coefficients of correlation obtained between rates of crushing and factory running costs. Each result is significant.

Year	*Co-efficient of Correlation*	*Pairs of Variables*
1920	—0.87	90
1921	—0.88	90
1924	—0.89	78
1925	—0.91	83

is practised. The yield per acre during a given time is, therefore, much higher in Java. In Mauritius the average yield per acre is considerably reduced by the fact that half the cane area is in the hands of Indians, whose primitive methods yield only 14½ short tons per acre. The virgin soil of Cuba tends to increase, and the practise of long ratooning to decrease, yields per acre.

Nor do costs of production afford us a reliable criterion of efficiency since rates of wages and labour efficiency vary so widely. In Java, with a population exceeding 35 millions, and an area of less than 50,000 square miles, the daily wage for unskilled male labourers is 20 cents. In Hawaii, with labourers recruited from 18 countries, the daily wage is about $1.50. Other average rates include Queensland $4.08, Cuba $1.20, Mauritius 84 cents, Natal 64 cents, the Philippines 36 cents, and Trinidad 45 cents.

Climatic and soil conditions, the length of the crop season, the type of sugar manufactured, local topography, the proportion of cane purchased, land tenure and values, and many other variable factors, introduce innumerable complications into comparative tests of efficiency. While the favourable peculiarities of certain countries indicate desirable goals, failure in others to attain them does not necessarily indicate inefficiency.

Since the development and prosperity of each country is largely dependent upon its ability to compete in world markets we may usefully study

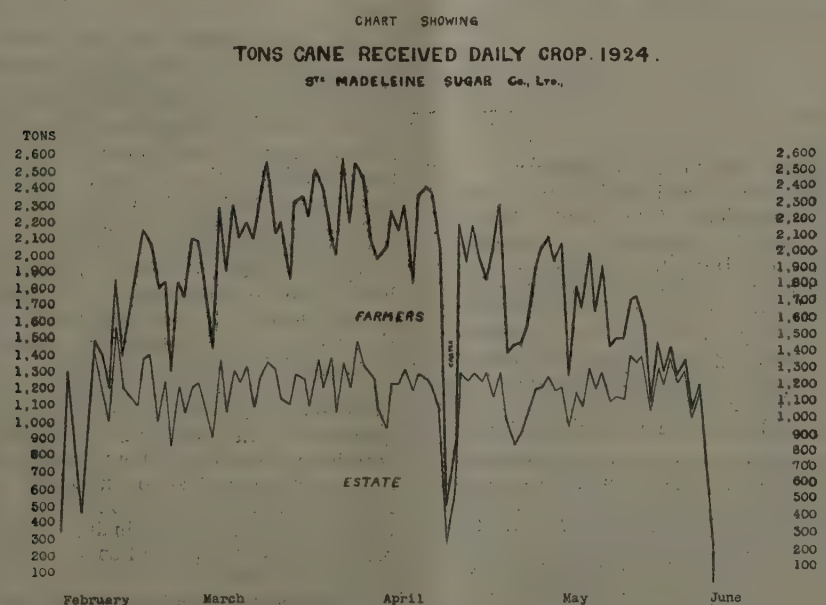


Figure 15.—Apart from small daily fluctuations the delivery of estate cane remains relatively uniform. The supply of farmers' cane varies considerably.

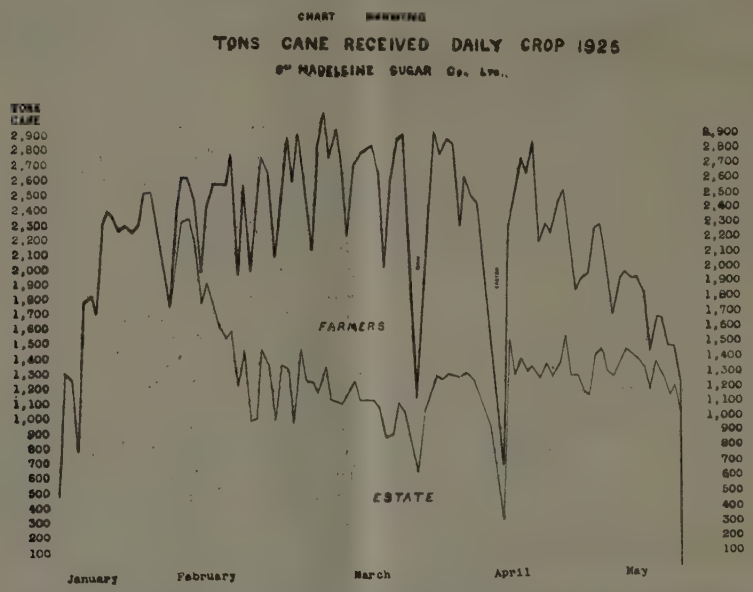


Figure 16.—The delivery of estate cane during the early period of the crop has been increased by hiring farmers' carts. The delivery of farmers' cane exhibits an irregularity similar to that for 1924. The aim of the estate is to reach the maximum capacity of the factory as early in the season as possible and to maintain that delivery throughout the season.

comparative costs of production. In Table XV an attempt has been made to reduce the costs of production to the same basis. (56)

TABLE XV.

COST OF PRODUCTION OF ONE TON (2,000 LB.) OF RAW SUGAR.

Java	$ 49
Cuba	50
Trinidad	55
Hawaii	68
South Africa	87
Queensland	121

These figures should be regarded as only approximately correct and subject to considerable yearly variation. One may, however, legitimately draw the conclusion that Queensland, South Africa and, Hawaii, can compete neither in the world, nor in their internal, markets without heavy subsidies or protection.(57) The difference in cost between Java, Cuba, and Trinidad, is relatively small. Java's sugar is normally marketed in the Far East, and only sporadically competes in the markets to which the British West Indies and British Guiana send their sugar.

(56) The figure for Trinidad has been calculated from the books of the S.M.S.C. for 1925 and 1926. The remaining figures are taken from Maxwell: *Economic Aspects of Cane Sugar Production; Norman Rodger.* Taxes have been omitted. A price of $68 per ton (2,000 lb.) of sugar, f.o.b. Port of-Spain, should enable an estate in Trinidad to realise 10 per cent. on its capital.

(57) The import duty on cane sugar into Australia is equivalent to $40.56 per short ton, and on sugar not otherwise specified $60.84.

Since the increased world production of sugar has depressed prices to an unprofitable level, one might expect those countries with the highest costs of production to be in dire straits. Such, however, is not the case, and, for the reason, one must make a cursory survey of the principal markets.

The United States and the United Kingdom are the principal consuming countries whose requirements are only partially met by internal production. The United States' consumption averages nearly 6 million short tons of which her internal cane industry supplies 2 per cent., her beet industry 16 per cent., and her insular possessions, Hawaii, Porto Rico, the Philippines, and the Virgin Islands, 25 per cent., all of which is admitted duty free, the equivalent of a protection of $44 per short ton. Hence Hawaii, in spite of her high cost of production, is guaranteed not only a ready market but also prosperity. Practically the whole of the remaining 3¼ million short tons is supplied by Cuba which enjoys a preference of 20 per cent. in duty, equivalent to $8.80 per short ton, which, with her low cost of production, guarantees a market but not prosperity. Cuba, with her production of about 5 million short tons, is therefore compelled to find other markets for about 1¾ million short tons. The Continental beet industry, protected in its internal markets, produces more than 1 million short tons in excess of its requirements.

Excluding India which produces, and consumes more than, 3 million short tons of low grade sugar, British production amounts to about 1½ million

short tons, and consumption to 3 million short tons. Nearly half this production is located in Queensland, and South Africa (58), where the internal protection is such that it not only guarantees prosperity, and thus encourages expansion, but also enables sugar to be exported at prices far below the cost of production. Since these Dominions enjoy Imperial Preference most of the surplus is exported to the United Kingdom.

TABLE XVI.

IMPORTS OF AUSTRALIAN AND SOUTH AFRICAN SUGAR INTO THE UNITED KINGDOM.

In 1000's tons.

From	1914	1920	1924	1925
Australia	9	1	44	88
South Africa	—	13	8	36
Total	9	14	52	124

The beet sugar industry in the United Kingdom, stimulated by heavy bounties (Table XVII) has rapidly risen to a production exceeding 200,000 tons, all of which finds a lucrative market

(58) Australia approximately ½ million tons and Natal ¼ million tons.

TABLE XVII.

BEET SUGAR INDUSTRY OF THE UNITED KINGDOM.

Amounts paid in subsidies.*

Period.	*Amount in pounds sterling.*
1924-25	492,040
1925-26	1,066,059
1926-27	3,225,858
1927-28	4,309,259
1928-29	3,250,000 (estimated)

* *West India Committee Circular, 1928, p. 317.*

in the United Kingdom. Most of the balance of British sugar is produced in the Crown Colonies, Mauritius, Fiji, the British West Indies and British Guiana, the bulk of which has to be exported. These Colonies, in common with all other Empire producers, enjoy a preference in the United Kingdom equivalent to about $16 per short ton, but share none of the additional advantages afforded to the Dominions and Home producers.

The United Kingdom consumes about 1¾ million short tons of sugar per annum. Before the War 66 per cent, of her supply came from Europe, Germany alone contributing 35 per cent. (59) In 1927, 70 per cent. of her imports came from foreign countries, Cuba and Europe being the principal sources. Canada, by a reciprocal treaty affords the British West Indies and British Guiana

(59) Average for the three years 1911-13.

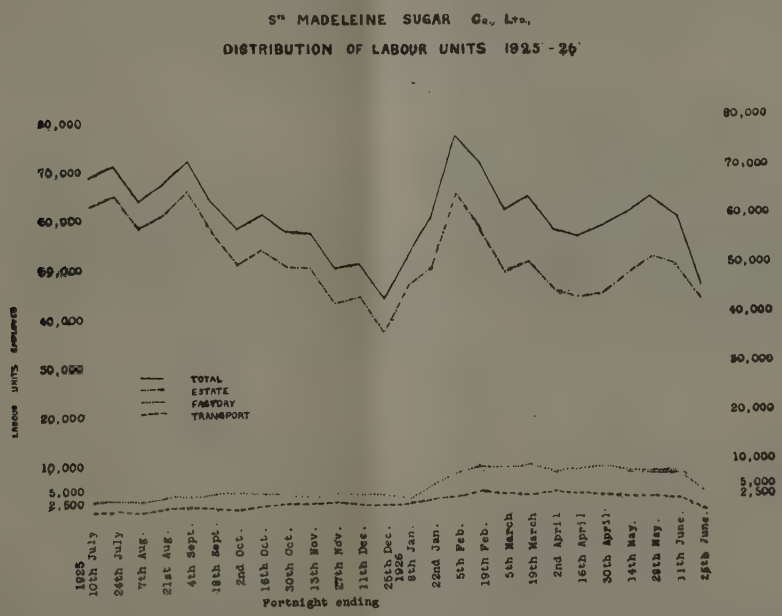


Figure 17.—The slight difference in the diagram between the total, and the aggregate units employed on estates, in the factory, and in transport, is represented by the numbers employed in handling shipments of sugar. During February-May, the crop season, every available unit of labour is employed. The peak in the early part of February is partly due to the employment of farmers for carting. During the remainder of the crop they are principally engaged in dealing with their own canes. Planting accounts largely for the heavy employment during August and September.

a preference in excess of that afforded by the United Kingdom, though the benefits to the producers approximate the same. The exports of the British West Indies and British Guiana are, therefore, divided between the United Kingdom and Canada, the latter country taking an annual average of 173,000 short tons during 1923-27. (60)

TABLE XVIII.

EMPIRE PERCENTAGES OF UNITED KINGDOM SUGAR IMPORTS.

1880	1914	1924	1927
24	9	16	30

The preference has stimulated the imports of Empire produced sugar.

Although these modest preferences guarantee a market to the British West Indies and British Guiana, and are vitally important, they by no means guarantee prosperity, and we have the anomalous position that, although the Colonies produce by far the cheapest sugar within the British Empire, they are the least prosperous. (61) With all sugar tariffs and bounties swept away, they alone among the British Empire sugar producers would survive (62), yet, under existing conditions, they are nearest to extinction. Sugar production in the British Colonies is more a political gamble than an economic proposition.

(60) Figures kindly supplied by Canadian Trade Commissioner.

(61) Although the cases are not parallel it is of interest to note that if the British West Indies and British Guiana enjoyed the same bounty as the United Kingdom beet industry nearly £6,000,000 would be available for distribution among the producers. The Ste. Madeleine Sugar Co. lost, on an average, $3 on every ton of sugar produced between 1921 and 1927.

(62) As before, India is excluded. Only 10 per cent. of the world sugar production is unprotected, 8 per cent. being produced in Java alone.

SUMMARY.

1. Sugar production has always been the subject of considerable political interference which, until the beginning of the nineteenth century, was calculated to foster and protect the British West Indies and British Guiana.

2. Throughout the nineteenth century the Colonies were the subject of political contempt, and the state-aided competition of the beet sugar industry brought the Colonial cane sugar industry to the verge of extinction.

3. Alternative crops were introduced, some islands gave up cane cultivation, cane areas shrunk and were consolidated, private estates gave way to companies factories were centralised, and yet the depression continued.

4. The West India Royal Commission, followed by the abolition of the bounty system, and the formation of the Imperial Department of Agriculture for the West Indies, marks a new era in Imperial politics. The interest in, and interference with, the Colonies by the Imperial Government has saved the Colonial sugar industry, but has not restored prosperity.

5. Each island has its own peculiarities, the salient characteristics of which have been briefly described together with the influence of the major pests and diseases.

6. In order to illustrate the methods of development a more detailed examination is made of a large sugar estate. The focus of research is shifting from the factory to the field and transport sections.

7. A survey of the world's sugar industry reveals the British West Indies and British Guiana in a favourable light yet, in spite of the fact that they produce the cheapest sugar within the Empire, they remain the least prosperous. Only improved political treatment, or increased prices, both of which appear remote, and are outside the control of the producer, can restore prosperity to the sugar industry of the British West Indies and British Guiana.

ACKNOWLEDGMENTS.

The writer desires to acknowledge his indebtedness to all who have assisted him in the compilation of this description, particularly the late G. C. Skinner, Esq., General Manager, and G. A. Jones, Esq., Acting General Manager of the Ste. Madeleine Sugar Company; his colleagues at the Imperial College of Tropical Agriculture, and Sir Francis Watts.

WILT DISEASES OF COCONUT PALMS IN TRINIDAD (Part I).

BY

H. R. BRITON-JONES, D.Sc., Ph.D., D.I.C., A.R.C.S.

Historical.

The coconut palm in the West Indies is known to be affected by two diseases both of which terminate in a rotting of the bud and are caused by specific organisms. These are the Coconut Bud-rot (*Phytophthora palmivora*) and Red Ring Disease (*Aphelenchus cocophilus*).

The aetiology of Bud-rot was, in the first instance, described by Butler (6) in India in 1906 and attributed to *Pythium palmivorum*. In 1919 the same author (7) re-named the causal organism *Phytophthora palmivora* by which name it is known at the present time. In 1920 Ashby (1) identified and proved the parasitism of *phytophthora palmivora* in connection with Bud-rot of Coconut palms in Jamaica. He has since shown (2) that the same disease is present in other West Indian Islands. The cause of Red Ring Disease was worked out by Nowell (12). Up till 1923, Nowell (12) was still of the opinion that apart from Bud-rot (*Phytophthora palmivora*) and Red Ring Disease (*Aphelenchus cocophilus*) there was still a third form of Bud-rot in the West Indies which was bacterial in origin. In 1926, however, Nowell (13) after further study of the third form concluded that the bacterial rotting of the bud was secondary.

Starting with the knowledge then that the two diseases known as Bud-rot (*P. palmivora*) and Red Ring Disease (*A. cocophilus*) occur in most of the West Indian Islands and the fact that the work of the above authors is of comparatively recent date one cannot but feel that some of the earlier publications grouped together under the one name of "Bud-rot" not only the above two specific diseases but also the third, already mentioned, with which this paper is concerned and to which Nowell (13) had given the appropriate name of "Wilt."

Stockdale (19) was the first to separate in the West Indies affections of the Coconut palm which resulted in a soft rotting of the bud, into more than one disease, namely root disease and Bud-rot. In the former he found a red discoloration of the trunk towards the outside which extended for a considerable length. Stockdale considered the root disease to be due to fungi and the Bud-rot to bacteria, stating that, in the case of root disease, the crown rot was secondary. The red discoloration of the tissues towards the outside of the trunk found in the case of root disease strongly suggests that the disease was what has since been shown by Nowell (12) to be Red Ring Disease (*A. cocophilus*) and that Stockdale was correct in stating that the rotting of the bud was secondary. The identity of Stockdale's "But-rot" is obscure since there has been a further separation in which the rotting of the bud is a symptom.

In 1911 Johnston (11) published a lengthy account of a disease of Coconut palms which he called Bud-rot and stated to be caused by *Bacillus coli*. Johnston's work was carried out in Cuba and other West Indian Islands including Jamaica and Trinidad. The author did not accept Stockdale's separation into more than one disease, nor did he accept Butler's earlier findings in connection with the *Phytophthora* Bud-rot in India. Butler made several successful inoculations with pure cultures of the fungus on both Coconut and Palmyra palms. Johnston's comment on these experiments was as follows :—"It must be noted that the inoculations were not made with pure cultures, at least not pure from a bacteriological point of view. This would seem to lay the results open to question." This comment is taken, of course, as a tribute to Butler's work. So far as can be gathered from his account of the Disease of Coconuts in the West Indies Johnston seems to have been definitely of the opinion that any disease of the coconut which eventually resulted in a soft rotting of the bud was due to *Bacillus coli*. He tends also to extend this conclusion to the Bud-rots of the Eastern Tropics. Furthermore, the author described successful experiments with more than one type of bacterial organism and when the technique used in inoculation is taken into

consideration the apparent success of the experiments is not surprising. After boring holes 45 cms. deep with an augur into the tender tissues at the crown of a coconut palm it is evident that not much else is needed to cause its death. Horne (10) stated that the disease in Cuba progressed during a long period of severe drought which caused the death of the resistent royal palms.

At the Imperial Botanical Conference in London in July, 1924, diseases of coconut palms which terminated in a rotting of the bud were fully discussed. Five Mycologists took part in the discussion, namely: Butler (India), Sharples (F.M.S.), Ashby (B.W.I.), Dowson (E. Africa), and Nowell (B.W.I.). In the published proceedings Butler (7) dealt with the Bud-rot which is now almost universally accepted as being caused by *Phytophthora palmivora*, and criticised Johnston's methods of inoculation with more than one kind of bacterial organism and expresses doubt as to whether there is any such thing as a primary bacterial Bud-rot of palms.

Sharples (17) put forward strong evidence that supported his conclusion which he expressed as follows:—"The writer (Sharples) is of the opinion that it would be advisable to consider rotting of the bud as a purely secondary phenomenon, following on attacks from widely different organisms, or resulting from changes in physiological conditions, small in themselves but which may release large potentialities." He also stated that careful comparative inoculation experiments with *Phytophthora Faberi* obtained from Prof. Reinking and *Phytophthora palmivora* obtained from Dr. Butler have been carried out in Malaya but no positive results have been obtained.

Ashby (3) differentiated between the Bud-rot caused by *Phytophthora* and those other diseases of Coconut palms which are known to die off with symptoms similar to Bud-rot in Cuba as described by Johnston. Amongst the causes of death he cites red ring disease, trunk-rot one or more ill-defined root troubles and severe drought. In regard to the bacterial Bud-rot disease in Cuba he states that the aetiology of this disease must be regarded as still obscure.

Dowson (8) described a disease which compares favourably with the Wilt disease in the West Indies. The author's observations of the conditions under which the disease occurs in the vicinity of Mombasa and those observed by the present writer in the West Indies are in some respects so similar that it is desirable to quote them at some length as follows "Palms planted round about the houses and between huts which are in the higher and therefore best drained ground were much larger, more vigorous, than others planted at the same time on lower ground. The former were always kept clean, in fact the ground was practically bare of other vegetation; the latter were growing in rank grass. Furthermore the former commenced to bear in the fifth year, whereas the latter never showed signs of bearing before the seventh year after planting. Bud-rot could not be found and has never been observed in the more vigorous palms about the houses and in the native encampment, whereas but a short distance away the disease was rife and the palms of Ceylon origin were without doubt the most susceptible." The author also explained the similarity between the outward symptoms of the Panama disease of Bananas and Bud-rot disease in Coconuts in East Africa. He pointed out that Brandes has shown that the yellowing of the outer leaves in Bananas is probably due to toxic substances secreted by the causal organism (*Fusarium cubense*) at the base of the plants. He suggested the possibility of a similar thing happening in the case of the East African Bud-rot but at the same time considered it unsafe to argue from analogy and that the yellowing of the outer leaves in the East African disease may be due to the downward movement of toxic substances emanating from an upper and more central seat of infection such as the youngest folded leaf.

Nowell (13) pointed out in regard to the disease in Trinidad that apart from the *Phytophthora* Bud-rot as described by Ashby in Jamaica there is another disease to which for the first time the author gave the name of "Wilt," since he considered the term Bud-rot to be a misnomer. His objection to the term Bud-rot is based on the fact that "in the early stages of the disease the central bud is found to be still quite sound and showing no signs of infection, although the tree is already certainly doomed." He further stated that "Wilt" develops into an epidemic and that it had been subjected to careful investigation for three or four years with results almost entirely negative. All attempts at artificial infection with cultures of bacteria from freshly invaded bud material, with small or large amounts of the affected tissues, and by transferring decayed roots had failed.

False Wilt.

Before proceeding to a description of the Wilt Diseases of Coconuts as observed by the writer in Trinidad and some of the other West Indian Islands it would perhaps be as well to consider in the first place the appearance of different types of healthy palms in Trinidad. As elsewhere, they differ greatly in appearance when examined critically. It is well known that the length of the main stalk of the leaf from the base (*i.e.*: the point of attachment to the trunk) to the point at which the basal leaflets (pinnae) are attached to the main stalk varies enormously according to the age of the palm. In young palms the distance is much longer and gradually decreases as the palm grows older. On the other hand, if one examines the lengths of the basal portions of the stalks in a plantation all the trees in which are of the same age it will be found, as previously described by Sampson (15), that the length of the basal portions of the stalk range from less than four to more than seven feet. Correlated with the differences

in length is a difference in the massiveness of the base and the thickness of the midrib. Those with base lengths of four feet or less have midribs which are much sturdier, thicker, and the area of the trunk to which they are attached is much larger than those with the longer lengths. A short leaf stalk is also correlated with a short fruit branch so that the bunch of nuts is nearer the trunk and the strain on the fruit branch and the supporting leaf is not so great as in the case of the longer types. These differences are due to the fact that the palms are of a different type which implies a fundamental difference in their genetic constitution. As explained below these differences are of paramount importance particularly from the point of view of crop production and it has also led to confusion in regard to Wilt Disease, and quite possibly Red Ring since the external symptoms of Wilt and Red Ring are much the same. When conditions are favourable to the production of a heavy crop of nuts by the thin leaf and long fruit stalk type it is found that the leaves are not strong enough to support the fruit. As the nuts grow and get heavier so the leaves are pressed down by their weight until eventually the bunch of nuts slips off the subtending leaf. A number of the nuts fall in consequence and a few others may remain for a time suspended to the fruit stalk which hangs almost vertically. In such cases the leaf remains green for some time. In others the bunches do not slip off but continue to exert pressure on the leaves weighing them down and thus causing them partially to sever connection with the trunk. This partial severing of the leaves at the base causes them to wilt and concurrently with this is a dropping of several of the nuts which have lost their adequate support. These are often mistaken for Wilt but can generally be recognised because the wilting is not so definitely progressive from the lower leaves upwards and secondly leaves which are still green can be found hanging almost vertically. This is in contra-distinction to the highly coloured yellow to bronze or reddish-brown colour in Wilt. Further the leaves are shed in the case of the latter and do not remain hanging for any length of time. Trees affected in this way following on heavy cropping do not die but take a longer or a shorter time, depending on conditions for growth, to recover from this abnormal defoliation before they come into heavy bearing again, when the same thing occurs. The percentage of these poor types of palms to be found in Trinidad and other West Indian Islands is considerable and the yield per acre must be adversely affected on their account. Both the good and bad types of palms are subject to Wilt Diseases.

Two Forms of Wilt Disease.

There are two forms of Wilt disease in the West Indies and in order to differentiate between them it is proposed to give them the names of "Bronze Leaf Wilt" and "Yellow Leaf or Tapering Stem Wilt." The latter is a chronic malady and its aetiology has not yet been worked out. Recently Park (14) has made a preliminary announcement to the effect that the fungus *Macrophomina phaseoli* (*Rhizoctonia bataticola*) has been found associated with root disease of coconut in Ceylon. "The symptoms of the disease of the young palms were a yellowing and subsequent death of the outer leaves which progressed inwards, dwarfing of the young central leaves, and, in extreme cases, a rotting of the central bud followed by death of the palm. The soil conditions were poor, being of a very sandy and dry nature with pools of brackish water in the vicinity. The palms in question were young, up to four years old. The investigation of this disease and of other supposed manifestations of root disease, for example, tapering, is in progress, but it is not yet possible to make a definite pronouncement as to the cause or causes or as to whether one cause is operative in all cases."

The above description of the symptoms of the Ceylon disease is similar to that of the "Yellow Leaf or Tapering Stem Wilt" in Trinidad. The leaves of palms suffering from "Yellow Leaf or Tapering Stem Wilt" turn yellow from the tips backwards and all leaves including the central ones become dwarfed. There is no bronzing or reddish-brown discoloration mentioned in the Ceylon disease nor is it present in the "Yellow Leaf or Tapering Stem" disease in Trinidad. No examination of the roots of such palms have been made in Trinidad so far. This will be done later but it is as well to point out even at this stage that trees suffering from the chronic "Yellow Leaf or Tapering Stem Wilt" often become liable to "Bronze Leaf Wilt" which is a separate disease.

Description of Bronze Leaf Wilt.

The lowest and oldest leaf of an apparently healthy palm varies in colour depending mainly on how long previous to the time of observation the tree shed its last leaf. In a really well-grown palm the oldest remaining leaf is green for some time after shedding the lowest leaf but turns with age to a yellow and later a bronze or reddish-brown colour proceeding from the tip backwards towards the base. Eventually the whole leaf including the stalk turns a deep brown colour and is defoliated in the normal manner. The next leaf, in turn, goes through the same cycle and so the palm produces new leaves and sheds the oldest ones in the normal process of growth and development. Very often, however, palms which cannot be described as diseased nor yet as vigorous palms will be seen to have the two oldest leaves showing the yellow to bronze colouring. In other words, the line between healthy and diseased is very narrow and it is almost impossible to decide where one ends and the other begins. On the other hand if the three lowest and oldest leaves show the yellow and bronze colouring described above coupled with the yellowing at the tips of the next two or three leaves, the extent of discoloration increasing with the increase in the age of the leaf, the palm is almost certainly affected by either

Bronze Leaf Wilt or Red Ring disease. The external symptoms of these two diseases are so much alike that the writer for the moment at any rate cannot possibly recognise one from the other with any degree of certainty, without preliminary testing in the trunk and leaf bases for Red Ring disease. The main point of difference between the external symptoms of the two diseases is that in the case of Bronze Leaf Wilt the wilting of the leaves progresses in order of age, that is the lowest leaf is almost always in a more advanced stage of wilting than the next one above it, and so on. This is also generally true of Red Ring but occasionally the younger leaf bases are attacked by the eelworm before the oldest and in such exceptional cases only can Red Ring be identified from Bronze Leaf Wilt by external symptoms. As Bronze Leaf Wilt disease progresses, and the same again applies to Red Ring disease as generally observed, the yellowing of the leaves extends up to still younger leaves but long before the youngest leaves show discoloration of any kind a bacterial rot sets in at the base and in the folds of the leaflets of the central spear of leaves. The rot later extends downwards into the cabbage. This bacterial rot develops to a considerable degree before the central spear of leaves changes colour but in the later stages of the rot they wilt turning a dull greyish-brown colour and fall over at the base. As described by Nowell (12) in the case of Red Ring and so it is with Bronze Leaf Wilt the shedding of green nuts takes place at the same time or slightly in advance of the discoloration of the leaves. Similarly the swords or spathes turn brown from the tips backwards towards the base slightly in advance of the discoloration of the tips of the leaves in the axils of which the swords are borne. It is possible, however, to see on the same palm open and healthy looking inflorescences in the axils of the younger unaffected leaves and spathes which have turned brown in the axils of the older and lower leaves.

In regard to internal symptoms the writer has not observed anything which can, so far as present knowledge goes, be considered diagnostic. Some of the affected palms which have been cut down at a point three feet from ground level show a reddening of the whole of the ground tissue which is indistinguishable in colour from the red coloration of the ground tissue within the red ring region of Red Ring disease. In his description of Red Ring disease Nowell (12) states that in very exceptional cases the discoloration in the stem as a whole is central. The reddening of the ground tissue is rare in the case of Bronze Leaf Wilt disease also and the majority of trees which have been cut down show no abnormal discoloration whatsoever. Search has been made for eelworms in the cases showing red discoloration but with negative results generally. Further investigation is necessary before the presence of the central discoloration in some cases and absence in others can be explained in the case of both Bronze Leaf Wilt and Red Ring, and the writer eliminates such cases from both diseases until further explanation is forthcoming.

Causes of Bronze Leaf Wilt.

An examination of trees in different stages of the disease suggests at once that the trouble is below ground and that it is due to a factor or factors which interfere with the functions of the conducting system. This is suggested by the absolute regularity with which the wilting of the leaves increases with age. On the other hand, the bacterial rot which is found at the bases of the youngest leaves even before they turn colour and the stressing of its great importance by Johnston (11) in connection with maladies of coconut palms in Cuba, Trinidad and Jamaica made it worthy of consideration. The line followed was the same as that previously adopted by Nowell (13), namely, to cut down trees in different stages of disease. When only four to six of the lowest leaves show symptoms of wilting, it is found that the tender tissues in the centre of the crown were white, firm, and perfectly healthy. As the disease progresses so the first stages of the rot can be found in different parts of the central tissues. In some cases a soft brown rot appears locally in small patches on the leaflets of the folded young leaves. Later the rot involves the basal tissues also and extends downwards eventually producing a putrid-smelling soft mass of rotting tissue. It is, therefore, a simple but a potent fact that both Nowell (12) and the writer have examined trees in the first stages of Bronze Leaf Wilt disease and found no trace of any rotting in the crown, nor of Red Ring disease at the bases of the leaves or in the trunk tissue. The writer, however, differs from Nowell (13) who stated that affected trees even before the bacterial soft rot appears are already certainly doomed. As will be shown later the subsequent death or recovery depends mainly on weather conditions. Whether recovery can take place after the soft rot has commenced is as yet undetermined. Sharples (17) has obtained recovery experimentally on a group of badly diseased oil palms suffering from a rotting of the buds by scraping out all the diseased bud tissue followed by placing a few handsful of salt in the cavity and transplanting them into the centre of the rows of healthy palms. It is, however, uncertain whether the causes of disease in the two palms are the same. In Trinidad the possibility of a connection between Little-leaf disease and late recovery from wilt has suggested itself to the writer and is now being examined.

Hundreds of roots both healthy and in different stages of decay have been carefully examined and many dozens of cultures have been made from sections and fragments of decaying roots collected in each of several estates. The fungus in the decaying roots is usually *Diplodia spp.* which is generally regarded as an early scaverger living on dying and recently dead tissue. Incidentally, the writer (5) has recently put forward evidence to show that there is no such thing as *Diplodia* Die-back of Cocoa or Rubber in the West Indies. The important (sic) fungus in Cocoa and Rubber being *Phomopsis spp.* This makes the genus *Diplodia* of less importance than even the little

previously attached to it as a parasite. Thus in spite of the fact that a very large proportion of the root system of Coconut palms suffering from Bronze Leaf Wilt disease are found in varying stages of decay, Nowell, Stell* and the writer have failed to associate any root invading organism with the disease. The only alternative explanation of the pathological condition of the plant is that it develops in response to external physiological factors. Based on observations of Bronze Leaf Wilt disease in Trinidad and St. Lucia the writer (4) has previously expressed the same opinion in regard to the disease as follows :—" Whether or not an organism is associated with the disease is not known but the writer's observations in Trinidad and St. Lucia suggest very strongly that the *prima causa* is a soil factor. The very definite correlation between lack of drainage and the incidence of the disease indicates that the organism, if there is one, is secondary. The trouble might be described as " Physiological drought " since it occurs on badly drained land and on land subject to desiccation during the dry season. Excessive soil moisture and too little moisture have the same physiological effect on the coconut palm as on a good many other plants."

Shepherd (18) has independently and more recently expressed the same views in regard to a disease of coconut palms in Mauritius as follows :— " The unhealthy appearance of the Coconut palms at Pointe aux Sables is attributed to the water-logged condition of the soil in some areas and to a deficiency of water in others, rather than to the presence of any specific soil organism. Inoculation tests with fungi isolated from diseased coconut roots (species of *Botryodiplodia* and *Chaetostroma*) have given negative results." A description of the disease was not given.

The cause of Bronze Leaf Wilt in Trinidad is, in the majority of cases, due to drought. By drought is meant that the soil becomes desiccated to such an extent that any moisture which is left is almost entirely unavailable to the plant. There is also the impression that possibly prolonged waterlogging will bring about the same result, but the writer now considers it desirable to prove this by further observations and experiments before any further definite statement can be made. The fact that the disease is worse on low-lying badly drained land and on lands with a permanent water table four feet or so below the surface of the soil suggests at first that waterlogging is the main cause. In Trinidad, however, it has been observed that the disease is very serious in some places on high sloping ground with no water table within several feet of the surface. It is important also to note that many hundreds of acres of coconuts in Trinidad are grown on land with a very heavy subsoil which becomes waterlogged in the wet season. The result is that the effective root system of the coconut is confined to the top foot of soil and sometimes only nine inches. On the same types of soil the lower the land the shallower will be the root system since it is wetter than the same type of land higher on the slope. On the other hand, a few roots do penetrate down to a depth of three to four feet in some cases. When the dry season sets in, the upper foot of soil in which the roots of the coconut, and incidentally those of weeds, are growing, becomes excessively dry within a few weeks and " Bronze Leaf Wilt " sets in at a later date. The time factor in this connection is of considerable importance both in regard to the time of the commencement of the disease and its termination in death or recovery. Examination of the small proportion of roots of diseased palms which do penetrate into the subsoil shows them to be in the main healthier looking than those in the surface layer. On the other hand the majority of them are flattened and twisted. This is not due to the fact that they have forced themselves in growth through stiff clayey subsoil and are thus flattened and misshapen but rather that in their growth they were normal in shape and size and that their abnormal shape is due to pressure exerted on their sides by the drying and contracting subsoil in the dry season. This contraction of Trinidad soils on drying is a matter of considerable importance.

The soils on which the disease is serious are generally heavy, in very bad tilth, and are constitutionally such that they do not drain well and they dry out rapidly and crack in the dry season. Coconut palms die of drought (*i.e.*: Bronze Leaf Wilt Disease) on land with a permanent water table within four feet of the surface, and also on land near fresh water streams which rise as the result of tide effect to within three feet of the soil surface. The impermeability of these soils appears to be so great that there is little or no upward movement of the subsoil water. Furthermore in the case of soils with a high water table, the water will probably, on analysis, be found to be brackish and would be of little or no use to the coconut palm. Examination of the root systems in such soils shows beyond doubt that with a good supply of sweet subsoil water the coconuts would still die from drought. It is also generally true of soils of different texture that the lighter soils in good tilth can support vegetation in a dryer condition than heavier soils in bad tilth. There is also evidence that there is a similarity between Coconut Wilt Soils and soils on which sugar-cane is subject to serious blighting as the result of attack by Froghopper (*Monecphora saccharina*).

Observations and Experiments.

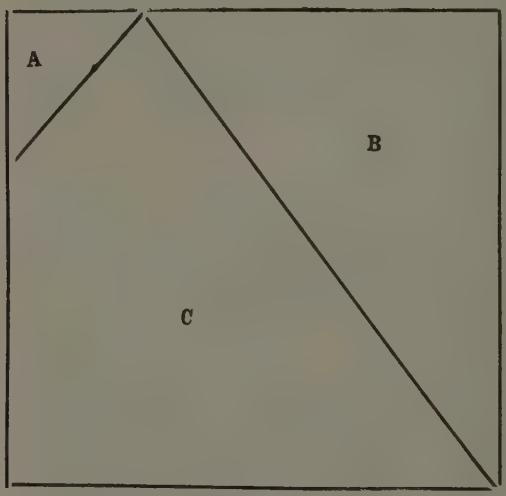
To support and to prove the validity of the statement that drought is the main immediate cause of Bronze Leaf Wilt, the effect of which is worse after a long and prolonged wet season, experiments have been carried out which have resulted in the production of typical symptoms

* Stell collaborated with Nowell in the work on Wilt.

of the disease as found in the field. Furthermore, the wilting of the leaves has been experimentally produced on one side of the palm only and in nearly all cases the extent of the symptoms produced corresponded to the extent of the treatment given.

Case I.—(St. Lucia.)

During a tour of inspection in St. Lucia in March, 1927, the writer made several observations on Bronze Leaf Wilt disease which led him to the conclusion already quoted. One case particularly is of considerable interest since it shows quite clearly the value of surface mulching and the superiority on some soils of sugar-cane grown as a catch crop with coconuts even without the application of pen manure over coconuts grown as a single crop without controlling the growth of weeds. The plot had been planted as shown in the following diagram :—



The subsoil throughout the whole plot was of a bluish clay, and the total area was somewhere about six acres. Section A was lower lying than sections B and C but was almost free of weeds. The coconut palms were of a cropping age and all were affected by Bronze Leaf Wilt disease to more or less a degree. Sections B and C were planted with coconuts which were four to five years old. In section B the palms were intercropped with sugar-cane which had been cut earlier in the season and at the time of observation the cane was making new growth but in addition the soil was effectively covered with the dry cane trash. In section C the ground between the palms was covered with a thick waist-high growth of grass and weeds. The condition of the palms in section C was very poor and although young palms the majority were showing marked symptoms of Bronze Leaf Wilt. In section B only one palm showed definite symptoms of the disease although there were others which appeared as if they would show symptoms later if the dry season continued. They were, however, in a condition which was markedly better than the palms in section C. This was very clear when comparison was made between palms left and right of the oblique line which formed the sugar-cane and weed boundary.

Case II.—(Waterloo Estate.)

On the 15th February, 1928, three healthy palms were selected, one being left untreated and serving as a control whilst the other two were treated as follows :—No. 2 a circular trench one foot wide and three feet deep was dug around the tree at a distance of five feet from the base of the palm. No. 3, a similar trench was dug round the tree at five feet distance in the form of a square. The palms were examined at different intervals and the following observations recorded :

Date of Observation.	*Palm No. 1. (Control).*	*Palm No. 2.*	*Palm No. 3.*
28.2.28.	Healthy	1 Leaf fallen. 2 hanging but green.	4 yellow bronze leaves.
5.3.28.	Healthy	1 leaf hanging, 1 with yellow tip.	5 yellow bronze leaves. 3 with yellow tips.
14.3.28.	Healthy	2 bunches of nuts hanging without support. 1 green leaf hanging. 1 bronze yellow tip.	5 bronze leaves 4 yellow bronze 1 with yellow tip.
21.3.28.	Healthy	1 fallen, 1 bronze yellow 1 with yellow tip.	3 fallen, 5 bronze 1 bronze yellow.

Palm No. 2 was a poor type but withstood the treatment far better than No. 3. This is not surprising since the soil varies enormously and in the field a few palms can be found still growing after the surrounding ones are dead.

Palm No. 3 showed typical symptoms of Bronze Leaf Wilt there being no observable difference between the Bronze to Yellow colouring of the leaves and others naturally affected by the disease. On the 21st March, 1928, palm No. 3 was cut down but no material rot had developed. This may be due to the fact that the treatment was sudden and drastic and the wilting of the leaves progressed much more rapidly than under normal field conditions, and the rot had not sufficient time to develop.

Case III.—(Waterloo Estates.)

On the 28th February, 1928, trenches were dug so as to isolate each of four healthy palms.

The distance of the trench from the palm was five feet in each case, so that the side of the square of soil supporting each palm was ten feet.

Date of Observation.	*Palm No. 1.*	*Palm No. 2.*	*Palm No. 3*	*Palm No. 4.*
5.3.28.	1 bronze leaf, 1 bronze yellow, several with yellow tips.	Healthy	Healthy	2 yellow bronze, 2 with yellow tips.
14.3.28.	1 bronze 3 bronze yellow, several with yellow tips	Healthy	1 bronze yellow, several with yellow tips	2 bronze 2 bronze yellow (the colour of the two leaves was not typical), several with yellow tips.
21.3.28.	3 fallen, 1 bronze hanging, several with yellow tips.	Healthy	1 fallen, several with yellow tips.	1 fallen, 4 bronze, several with yellow tips.

Case IV—(Waterloo Estates.)

A circular trench was dug round one of three healthy palms of ten years old at a distance of five feet from the trunk.

Observations.

5th March, 1928—No sign of response to treatment.

14th March, 1928—4 leaves with yellow tips.

21st March, 1928.—1 bronze yellow, 1 bronze yellow tip, 4 yellow tips.

Case V.—(Plein Palais Estate.)

On the 17th February, 1928, the soil on one side only of a healthy palm was dug lightly to a depth of three inches. This necessitated the cutting of the root system within the cultivated area. On the 29th March, 1928, the three lowest leaves on the side of the palm where the soil was dug had turned to a bronze yellow colour. These were all younger than the oldest leaf which was green and on the opposite side of the crown. On the 21st March, 1928, the three discoloured leaves had turned a deep bronze colour but there had been no discoloration of the other leaves.

Case VI.—(Inverness Estate.)

On the 29th February, 1928, five healthy palms of a bearing age were selected for experiment. Nos. 1 and 2 were given no treatment and served as controls. The treatment applied and the observations made are given in the following table :—

No. of Palm.	*Treatment.*	*Date of Examination.*	*Remarks.*
1	No treatment (control).	14.3.28.	Healthy.
2	No treatment (control).	14.3.28.	Healthy.
3	Circular trench 1 ft. wide, 3 ft. deep dug round palm at a distance of 5 ft. from trunk.	14.3.28.	1 bronze leaf 2 yellow bronze 3 yellow tips.
4	A patch of soil comprising ¼ of the whole under the palm was dug to a dept of 6 inches	14.3.28.	1 Bronze leaf and 1 with yellow tip on side corresponding to the area which was dug.
5	The soil on one side of the palm comprising a half of the whole was dug to a depth of 6 inches	14.3.28.	2 leaves with bronze yellow tips on half of the palm corresponding to treated soil area.

Further observations will be made on the treated palms in the above experiments.

Control Measures.

There is still much work to be done on Bronze Leaf Wilt disease and the following suggestions are put forward in regard to control measures in the hope that they will be experimentally tested by planters. Indeed, the very nature of the disease is such that hard and fast prescriptions cannot be given which will be applicable in all cases. In considering remedial measures for disease in crops it is essential at all times to bear in mind that gold can be bought at too dear a price. This is true to a large extent in this case so that the planter's inevitable question following failure in coconuts must at least be discussed although tentatively at the present time. The underlying principles for control can be outlined but the detailed measures to be taken vary between different localities depending on the degree of unsuitability of the soil and other factors including available labour. In the application of the principles planters are advised to refer the matter to their advisory officers and to have their soils examined.

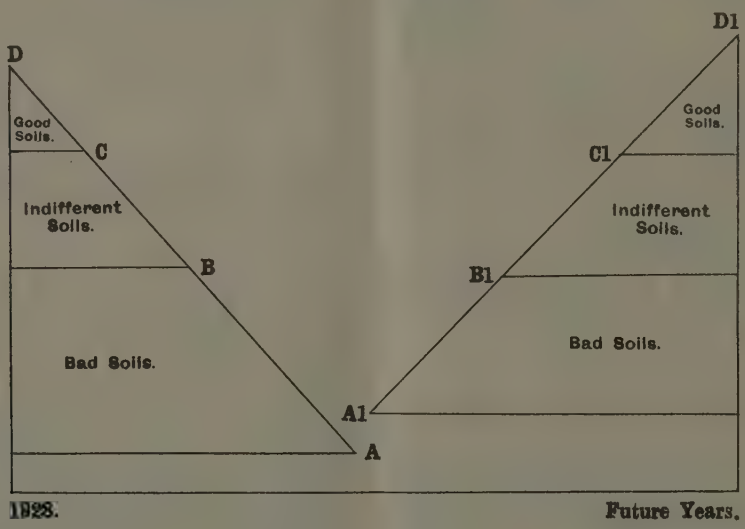
Control measures come under two headings namely (1) " Preventive Measures " to be applied to plantations in a young state and to those lands not yet planted in coconuts ; and (ii) " Palliative Measures " to be applied to plantations already established and in a cropping condition. The three lines of work which are clearly indicated at the moment are (i) Soil Improvement (ii)Drainage and (iii) Cultivation.

PREVENTIVE MEASURES.

(1) *Soil Improvement.*

The means by which the soils can be improved is in the hands of soil Chemists. Two workers Hardy (8) and Turner (20 & 21) have already obtained significant results in their research work on Trinidad Sugar-Cane Soils in connection with the varying degrees of blighting on different lands following attack by the Froghopper (*Monecphora saccharina*). Hardy (9) has shown that there is a definite correlation between the degree of acidity and the amount of blighting. Sugar-cane grown on soils with low pH values suffer much more severely from blighting than those grown on soil with a higher pH value. Turner (19) has shown that the blight-free soils are invariably rich in exchangeable calcium, irrespective of the type to which they belong, and are in good physical condition, as compared with soils on which sugar-cane becomes severely blighted. Both workers have recommended the application of lime as a soil ameliorant to the soils in poor condition.

The good black soils can be recognised by eye from the lighter coloured poorer soils and a survey of Bronze Leaf Wilt disease in Trinidad and observations on the types of soils in regard to tilth and moisture content suggest a similarity. The disease occurs also on soils which are black only to a depth of six to twelve inches and overlying impervious clay. It is significant to note that much of the area under coconuts at the present time was previously under sugar-cane. The change of crop was to a large extent decided upon because of the fact that sugar-cane on these lands was subject to severe blighting following attacks by froghopper. The manner in which land which was previously under sugar-cane has been brought under coconuts is of importance in the consideration of Bronze Leaf Wilt particularly in regard to drainage system.



The above figure represents in a general way the writer's conception of the range of suitability of soils under coconuts in Trinidad at the present time and the economic possibilities in the future. The lines AB, BC, and CD represent the suitability of the soils under coconuts at the present time and the lines A1B1, B1C1, and C1D1, represent what is practicable in the future as the result of chemical research and suitable agricultural operations. The figure is more correct qualitatively than quantitatively since it is readily admitted that from the latter point of view the length of the lines BC and CD are generous to say the least.

A preliminary survey of the occurrence of Bronze Leaf Wilt in Trinidad coupled with field tests in regard to root range and type of soil indicate that there is a definite similarity between the prima causa (soil factor) of the disease and those of sugar-cane blight, although these may affect the two crops somewhat differently. The Bronze Leaf Wilt occurs in the dry season mainly whereas blight occurs in the wet season. Nevertheless, it would be interesting to investigate the question of soil moisture relationships in regard to sugar-cane blight also.

It will be seen from the above diagram that some of the areas now considered indifferent soils for coconuts can be made good and what are good can still be improved. Further, a section of the soils which are now definitely bad can be improved and made into indifferent soils on which economic although not good crops can be grown. Finally, the section A1B1 will, in spite of the weapons at the disposal of soil chemists and agriculturists up to the present time, still remain bad and on which no paying crop of coconuts will be grown. Possibly if

large amounts of money and labour were spent all A1B1, soils could be made indifferent or even good according to the amount expended but that would not be economically sound. Thus, the conclusion is arrived at that an economic means of preventing the disease is possible on a number of soils. These are the indifferent soils and the best of the bad soils. Furthermore, it is the writer's considered opinion that the poorest soils cannot profitably support any really permanent crop and it will be as well not only to select a short life crop which can be sown and harvested more or less within the limits of the rainy season, but to select these after careful experimental trials. The land could be limed and ploughed at the beginning of the dry season, and left fallow until the following wet season when the crop could be sown after deciding the optimum date of sowing as the result of experimental trials. In the first season the cost of weeding even quick-growing leguminous crops may be heavy but as time goes on cultivation expenses will be reduced. Furthermore, the land will continue to improve and as previously stated some of the present bad lands will improve to such an extent that they may then support a more profitable crop like sugar-cane or coconuts. There is no short road to success and in some cases conditions are so bad that even the first crop of legumes may require a stimulating dressing of manure in addition to liming and weeding. Sampson (16) in a recent report has suggested Rice as a Rotation crop for sugar-cane on some of the lands in Trinidad so that this possibility suggests itself in regard to some of the lands which cannot profitably support coconuts owing to Bronze Leaf Wilt. Rice is, however, not recommended by the writer since he thinks it is very doubtful indeed whether there is sufficient labour available for this crop on a large scale in Trinidad. The question of labour is one which must be taken into consideration in regard to the writer's proposals also and in some localities it will undoubtedly be found to be a governing factor.

Drainage and Cultivation.

When the tilth and general fertility of the soil is improved the question of drainage will to a large extent solve itself. The present method on the better lands is successful although there is an indication that perhaps it is being rather overdone so far as coconuts are concerned. Cultivation of coconuts in Trinidad even on good lands of heavy texture is not to be recommended. The root systems in the main are still shallow and ripping up the surface soil is a danger. It is futile to attempt to induce deeper rooting into a heavy subsoil where conditions of aeration are bad. The writer as the result of extensive observations on root range in different soil types good and bad does not advocate cultivation but favours covering the land with a vegetable mulch in the dry season. This is more fully discussed below.

Palliative Measures.

Drainage.

Drainage is considered first under "Palliative Measures" since these are applicable to lands already under coconuts and the drains are there and are to be made use of as the means whereby the measures necessary for soil improvement can be put into operation.

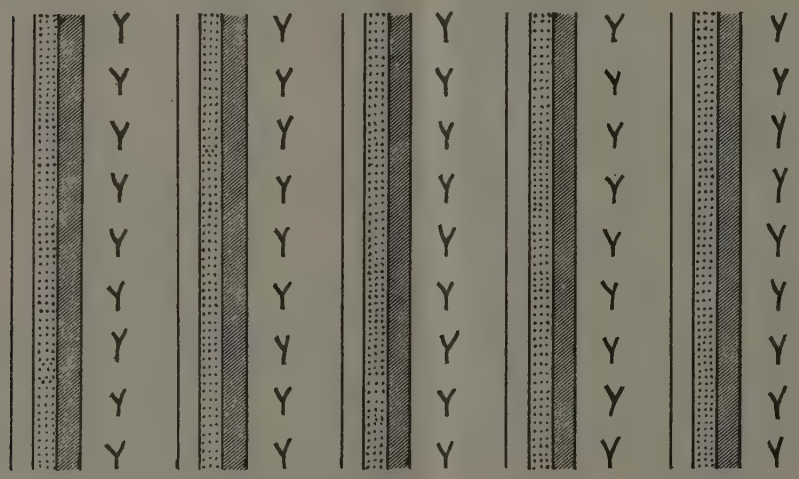
There is an amazing similarity between the methods of drainage on all the widely varying types of soils under coconuts. It seems reasonable to conclude, therefore, that the same system cannot be the best for all localities. Apart from type of soil the method and extent of draining hillsides is the same in the main as that on low-lying lands. The reason for this is due to the method used in the establishing of coconut plantations in place of sugar-cane. The sugar-cane beds have drains on each side and the width generally averages from 15-20 feet wide. On several coconut estates, however, they are less and rarely more than 18 feet and sometimes 10-12 feet only. This is well below the average on sugar-cane land at the present time but it must be remembered that it is the poorest sugar-cane lands which have been put under coconuts in the past. In the majority of cases the coconut palms were planted in the cane beds on the edges of the drains to avoid their being damaged by carts when the cane was reaped.

It has already been stated that the soils on which coconut palms suffer severely from Bronze Leaf Wilt do not drain well and dry out quickly in dry weather. To illustrate the inability of some of these soils to drain a test has been made by various persons in the following manner. A hole about a foot deep and a foot wide is dug in the bed at a distance of a foot or so from the edge of the drain. This is then filled with water when the soil is wet. The water remains in the hole for several days although within a foot of the open drain. When the hole does dry up it is mainly as the result of evaporation. It seems, therefore, that drains at a distance of 15 feet apart is not an efficient drainage system on these poor types of soil. Their main function is to carry off surface rain water. When the dry season comes in, however, there are many open drains the sides of which are dried up in a few weeks by sun and wind. The surface of the beds are also dried by wind and sun coupled with the absorption by the coconut palms and a covering of weeds more often than not 2 to 4 feet high. Coconuts in the high winds in the dry season transpire more rapidly and require more water therefore than in the wet season. Apart from anything else if the beds were round-ridged and widened so as to reduce appreciably the number of drains the conditions would be improved against Bronze Leaf Wilt. This must not, however, be overdone and it is doubtful whether, before the soil tilth is improved, it is at all possible to devise a drainage system which will keep the soil from becoming too wet in the wet season at the same time avoiding its becoming

too dry in the dry season. Wider beds and round-ridging are, however, essential to avoid Bronze Leaf Wilt since by this means the surface water will still be effectively carried off in the drains remaining; furthermore, it will mean that there will be a considerable increase of soil per tree which would not dry out so quickly owing to the fact of there being fewer open drains. The manner in which fewer drains can be substituted for the many and too frequent drains in an established plantation without firstly, making the conditions too wet in the wet season and secondly, without hopelessly damaging the palms and in fact producing Bronze Leaf Wilt disease in the process is the problem to be settled.

Change of Drainage System.

The danger of digging new trenches and damaging the roots in the dry season has already been explained. Where the beds are narrow very little digging will be necessary since every other drain can be filled in not with soil only but a mixture of soil, brushings from the beds there being plenty of this material to hand, and lime. This should be done with judgment since the vegetable matter in the process of putrefaction will shrink in bulk and there will be danger, unless the canals are filled to well above the general surface of the reformed bed, of water-logging with its attendant evils in the wet season. The reformed beds should be round-ridged to ensure efficient running off of the water. In the case of beds which are not narrow enough to make two beds out of one and as is generally the case not really wide enough in themselves there are two alternative suggestions which can be made.



The above figure represents a coconut plantation which has been established after sugar-cane. The shaded portions are the old sugar cane drains with the coconuts planted beside them. The dotted portions represent the position of the drains as they should be reformed in the first instance. The unshaded portions represent the final position of the drains. It will be seen that with the drains in their final position the palms will be at or very near the middle of the beds. This can only be done gradually by digging or ploughing along one side of the beds and using the soil removed together with brushings of weeds and lime to fill in the older drain. This should be done in the wet season when the drains are free of water although the soil will be wet. *On no account should the lime and weed brushings be omitted, otherwise the main object will be defeated.* The second operation may be done in two or three years after the first, after which most of the soil will have received its required treatment. The above two systems may, in some cases, be combined. The second alternative is to cut down the palms in the worst affected areas, and to resort to the Preventive Measures already described.

Close Planting.

In all plantations where Bronze Leaf Wilt has been recorded, and in the majority of plantations where the disease does not occur, the palms are planted generally at what appears to be just about half the proper distances apart. Taking the effective root range to be one foot in depth and the average width of the beds and distance

of planting to be fifteen feet it follows that the coconut palm has 225 cubic feet of poor soil from which to obtain its nutriment and water supply. It is no wonder, therefore, that the palms take fifteen years to produce a crop and that as a result of its production and the additional strain on the root system, the palms die from Bronze Leaf Wilt. No optimum distance of planting is given here since there is already too much tendency to generalise in this respect. As with Cocoa and other tree crops the optimum distance of planting varies with the type and suitability of the soil and must be decided as the result of observations or experimental trials in individual plantations. A good guide is given by Sampson (14) who states that "The distance of planting should be four feet less than twice the length of a well developed leaf of a full grown bearing tree." It must be borne in mind, however, that what would be considered a well developed leaf in Trinidad would not be considered so on the good coconut lands in St. Lucia for example; furthermore, when the tilth and fertility of the soil is improved in Trinidad naturally the length of the leaf will increase.

Time and Frequency of Brushing.

To replace weeds by a cover crop in established coconut plantations in Trinidad is not possible since this means cultivation against which reasons have already been given, and apart from these there is again the labour problem. The only means of controlling weeds is by brushing periodically. Much has been said against weed growth in coconut plantations in Trinidad and reference has already been made to it in this paper. Objection has, however, been raised herein in connection with growing weeds in the dry season only and not against weeds in the wet season. The question of the advisability or not of frequent brushings in the wet season is a matter for further investigation, since there is the possibility that it may do more harm than good. The amount of soil moisture present in the wet season is well above the optimum for coconuts, and weeds in growth take up a considerable amount of this excess moisture. Furthermore, weeds are the main mulching material which is available for covering the land in the dry season. With frequent brushings throughout the year the growth of weeds will be reduced and in the dry season there will be little available mulching material. On the other hand if weeds are allowed to grow in the wet season they will on cutting make a good cover which will take a long time to putrify in the dry season and will incidentally tend to smother subsequent growth. It takes time to brush large estates but the best time to begin would be just before the beginning of the Indian Summer when brushing should be done first on the poorest lands which are liable to dry out. The work should continue throughout the remainder of the wet season following the Indian Summer and all effort should be made to keep down weeds in the dry season. The control measures suggested above are now being tested on a financial basis in five different localities on the Waterloo Group of Estates in Trinidad. The total acreage under treatment is about thirty acres and control plots are being kept for comparison of yields, and incidence of the disease.

* * *

Summary.

1. Two forms of Wilt disease, namely, "Bronze Leaf Wilt" and "Yellow Leaf or Tapering Stem Wilt" are described

2. The main cause of "Bronze Leaf Wilt" is shown to be drought which does not imply a prolonged dry period but becomes evident after a short dry period under certain soil conditions particularly those in bad tilth.

3. Typical symptoms of Bronze Leaf Wilt have been reproduced under experimental conditions.

4. Control measures are discussed under two headings: "Preventive Measures" and "Palliative Measures" which are to be applied to lands not yet planted and young plantations, and to plantations already established.

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* * *

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WILT DISEASES OF COCONUT PALMS IN TRINIDAD Part (II).

BY

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Introduction.

THE confusion which has existed in the past in regard to the different maladies of Coconut Palms which have been grouped under the name of "Bud Rot" is gradually disappearing as the result of work carried out in different parts of the Tropics. In a recent paper Sharples (6) working in Malay has described a hitherto unknown disease of the African Oil Palm (*Elaeis guinensis Jacq.*), as well as of the Tall and Dwarf Coconut Palms. This disease is caused by the fungus *Marasmius Palmivorus* Sharples, which apparently often grows saprophytically at the bases of the leaves, where they are closely adpressed to the stem. Under certain conditions, however, the fungus becomes parasitic attacking the bases of the leaves thus causing defoliation and ultimately the death of the palms. In this connection Sharples (6) puts forward the suggestion that "it may be possible that further investigation in the West Indies may disclose results which will have a probably significant degree of similarity with those in Malay." So far the disease caused by *Marasmius Palmivorus* has not been observed in Trinidad but as Sharples suggests there is always the possibility that it may be recorded at some future date. The most serious trouble in Trinidad is Bronze Leaf Wilt the symptoms of which are different from those caused by *Marasmius Palmivorus* Sharples. Plate I shows the clean break of the leaf bases in Bronze Leaf Wilt and the absence of lesions such as are caused by *M. Palmivora*. Under the heading of Control Measures on Tall Coconuts Sharples (6) differentiates between three affections of the Tall Coconut Palm. These are (*a*) cases of typical Lightning-strike; (*b*) Damage caused by *Marasmius Palmivorus* and (*c*) Retrogression in areas where growth conditions are unsuitable. In case (*c*) the symptoms as described by the author are similar to those of Bronze Leaf Wilt in Trinidad. Furthermore, the following extract suggests a general similarity in causes even if, as is possible, they are not the same. "In conjunction with these sanitation methods, measures designed to improve soil conditions should be undertaken. There is little definite knowledge regarding methods to be adopted, but applications of a lime and fish manure mixture have brought about definite improvements in 12 to 18 months' time. Other methods are in operation but it is too early to state whether they will be successful or otherwise. Further reports on these features will be issued later as definite results are obtained."

It would seem, therefore, that the problem which presents itself in Malay in regard to affection (*c*) is very similar to the problem in other parts of the Tropics including East Africa (2) and the West Indies. On the other hand, the probability is that the manner of solving the problem in one colony will not be applicable to the other. Various local factors must be taken into careful consideration such as, the price, efficiency, and availability of labour supply, differences in drainage systems and their limited influence on conditions, amount of livestock, coupled with the possibility and the advisability or otherwise of implemental tillage at certain periods in the year, and lastly the causes of the unsuitability of the conditions in different soils may be entirely different. In one case it might be due primarily to the physical texture of the soil whereas in another it might be due to the chemical composition of the soil or even a combination of certain physical and chemical factors.

The present account by no means concludes the work on Bronze Leaf Wilt of Coconut Palms in Trinidad, and is written at its present stage in response to a request for a progress report which has been made by Trinidad planters particularly interested in Coconuts. Furthermore, the study of the disease has reached a stage at which definite conclusions have been arrived at concerning the future of coconut cultivations in localities where the disease is already known to planters. More particularly attention is drawn to the fact that unmistakable signs of future trouble can be recognised in many young plantations at the present time.

When Part I ([1]) of the study of Wilt Diseases of Coconut Palms in Trinidad was published the writer stated that "The cause of Bronze Leaf Wilt in Trinidad is, in the majority of cases, due to drought. By drought is meant that the soil becomes desiccated to such an extent that any moisture which is left is almost entirely unavailable to the plant. There is also the impression that possibly waterlogging will bring about the same result, but the writer now considers it desirable to prove this by further observations and experiments before any further statement can be made." That is exactly the position which the writer still wishes to take in regard to Bronze Leaf Wilt. This disease develops to a fatal extent in hundreds of palms annually in the dry season. It also manifests itself to a less serious extent in hundreds of thousands of other Coconut Palms. With the advent of the wet season a very large proportion of the latter recover and produce crops whilst others recover temporarily only to succumb to the disease later during the same wet season. The disease in the wet season may be due to excessive soil moisture but the writer is not prepared to forsake a cautious attitude on this point and before he commits himself he must first reproduce wilt symptoms by waterlogging under experimental conditions. In this respect it is necessary to differentiate between direct effects of waterlogging such as lack of aeration, and indirect effect consequent on soil changes. Excessive soil moisture and lack of aeration combined possibly produce a complex which influences adversely the growth of nitrifying bacteria in the soil. This may explain why it is that in Trinidad there are two definite periods following dry weather during which there is a flush of growth and a cessation of growth when the wet season is well advanced. Furthermore, the sudden marked changes in the atmospheric humidity need to be considered. These factors affect many crops and many wild plants and it would be unsound to ignore their possible influence on the incidence of Wilt in Coconuts. Indeed, before Bronze Leaf Wilt disease can be thoroughly understood a vast amount of work must be done on the physiology of the healthy coconut palm. So far little is known and it would be wild speculation to attempt to explain fully the fundamental reasons for a diseased condition before several simple questions can be answered concerning the healthy. From Arima southwards as far as San Fernando it is doubtful whether there is a single bearing palm in a coconut plantation which might truly be described as healthy in the strict sense of the term. The term healthy in the accompanying tables is, therefore, used in rather a more comparative sense than usual. Such an attitude is essential before the little that is known about the disease can be understood.

Experiments and Observations.

The following experiment was carried out with a view to proving whether drought was one of the causes of Bronze Leaf Wilt disease. Three palms suffering from the disease were situated within easy reach of a fresh water stream. It was decided to remove obviously discoloured leaves and all nuts. To avoid bleeding the trunks the discoloured leaves were removed by cutting with a cutlass at a distance of 18 inches or so from their bases. The weeds around the trees were brushed with a cutlass. The periodical watering, which was done by means of a bucket, was for some time inadvertently given only to the soil round the bases of the palms within a distance of five feet roughly. Later it was applied to all the soil which was available to the particular palms. The following tables shows the condition of the palms before and after treatment :—

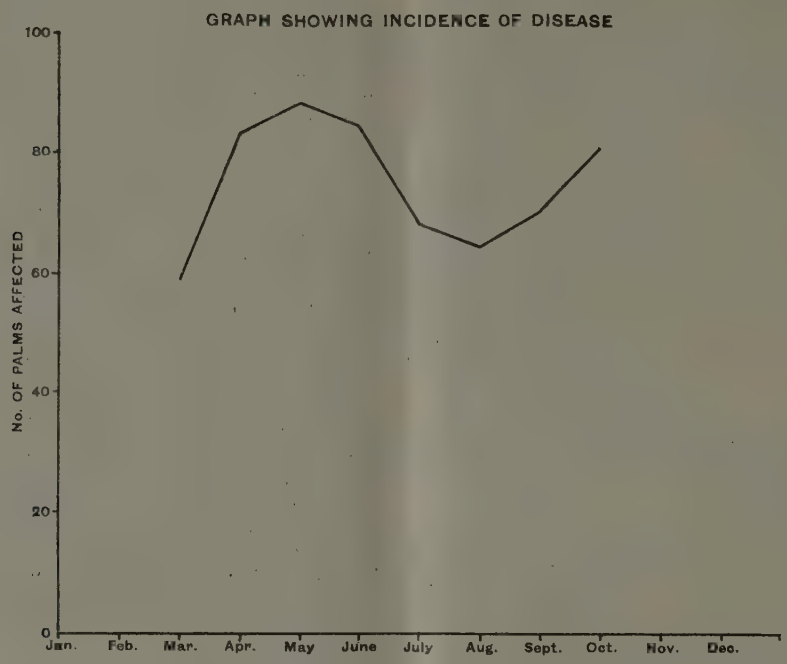
No. of Palm.	Condition of Palm before treatment.	Dates of Observations.	Remarks.
I	3 Bronze-yellow leaves. Several leaves with yellow tips.	29. 2. 28.	Weeds brushed and all nuts and discoloured leaves removed.
		30. 2. 28.	First watering given. Soil kept moist with additional water from this date onwards.
		14. 3. 28.	Wilt progressing. Water so far only given to few feet of soil round palm.
		24. 4. 28.	No further progress of Wilt although watering only given to soil within five feet of trunk.
		9. 5. 28.	As from 24.4.28. There was no further advance of the disease and the palm improved in condition as time went on. No watering given after beginning of wet season.
		31. 10. 28.	Palm healthy. Producing crop.
		17. 12. 28.	Healthy and heavy in crop.
II	3 Bronze-yellow leaves. Several leaves with yellow tips.	29. 2. 28.	....
		1. 3. 28.	Weeds brushed, nut and 3 leaves removed. Watering begun although within limited radius as in case of Palm No. 1.

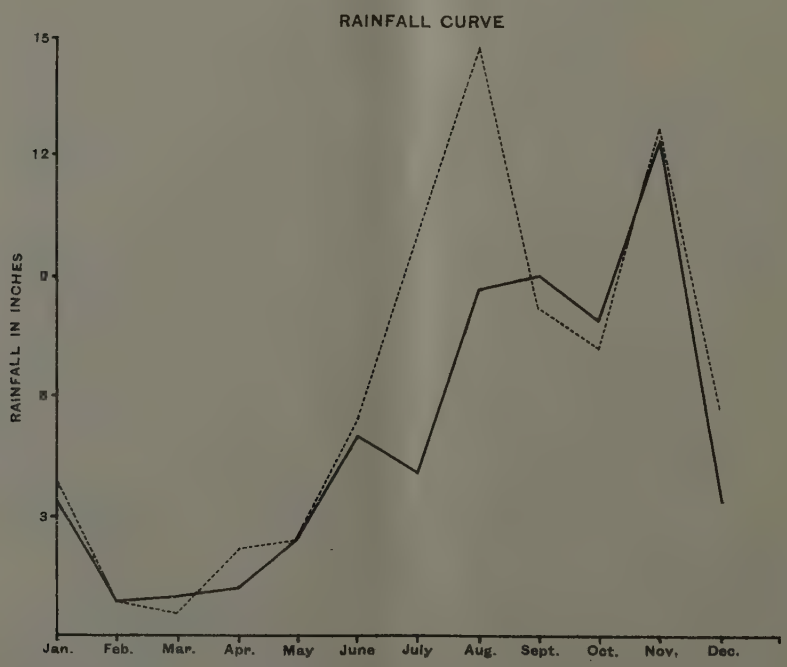
No. of Palm.	Condition of Palm before treatment.	Dates of Observations.	Remarks.
II	3 Bronze-yellow leaves. Several leaves with yellow tips.	14. 3. 28.	1 yellow tip only. Watering as before.
		24. 4. 28.	No further progress of disease. Watering as before.
		9. 5. 28.	No further progress of disease. Watering as before.
		31. 10. 28.	Palm healthy. Producing nuts. Recovered.
		17. 12. 28.	Healthy cropping.
III	10 Bronze-yellow leaves. Several yellow Tips.	29. 2. 28.	—
		1. 3. 28.	10 leaves removed, weeds brushed, soil watered as in Nos. 1 and 2.
		14. 3. 28.	Disease progressing rapidly.
		24. 4. 28.	Bud Rot stage of disease.
		9. 5. 28.	Last stages. Tree cut down.

In spite of the fact that the watering was confined to the soil within five feet of the bases of the trunks Palms Nos. 1 and 2 which were given treatment in time recovered. The disease was too far advanced at the beginning of the experiment in Palm No. 3 and it died in spite of the treatment. Subsequent observations on groups of palms on the same and other estates showed that there is a certain percentage of natural recoveries. In view of this fact it might be thought that too much significance might be paid to the above result. As previously stated ([1]) it is often extremely difficult to decide whether a palm can be considered healthy or diseased. It is a question not only of the number of leaves showing discolouration but also of the extent and degree of the discolouration. On the other hand, with practice it is possible to recognise that one palm with several discoloured leaves is on the way to recovery whereas another showing, to the casual observer, symptoms less marked nevertheless indicates that the disease is progressing rapidly. It would be a hopeless task to attempt clearly to convey how this can be done without actual demonstration on diseased palms in the field, and even then it would be rather difficult. It is a matter of training the eye to differentiate between different shades of yellow and different shades of bronze or reddish-brown, as well as the amount of each. Just as it is essential for a planter to be able with a glance to state that a certain field of sugar-cane is not "*doing well*" without it necessarily ever getting into what might be described as a pathological condition, so it is essential in the present case to be able to differentiate between different degrees not only of health but also of disease. Furthermore, the presence or absence of otherwise unimportant diseases caused by Diplodia, or Pestalozzia, &c., depends to some extent on the rate of progress of the Wilt disease. Again there are several palms which show yellow tips on all but the uppermost leaves but which, nevertheless, may never show symptoms of Bronze Leaf Wilt. The yellowing of the tips is different in tone, in extent, and in distribution from that in Wilt and is associated with Yellow Leaf or Tapering Stem Wilt which is possibly due to a deficiency of available nitrogenous food material in the soil. On the other hand, some palms suffering from Tapering Stem may develop Bronze Leaf Wilt so that it is extremely difficult accurately to assign to each malady its true value in the complex of symptoms. When all these points are taken into consideration in the above experiment the writer has no hesitation in saying that Palms Nos. 1 and 2 did recover as the result of the watering.

Explanation of Tables and Graphs.

The accompanying tables and graphs showing the incidence of the disease on a number of palms in different estates throughout the period of one year lend further support to the above conclusion. In Table I the letter R denotes the fact that the palm in question suffered from the disease and recovered later. The word "Wilt" means that the symptoms as shown by the number and extent of discoloured leaves were sufficiently advanced to justify a definite diagnosis. Sometimes it is necessary to refer to previous observations before this can be done. Tables II and III show the observations made on palms which recovered from the disease and are specially selected for that reason from plots of seventy to eighty palms on which similar observations were carried out on different estates. The observations in Table I were made by the writer in collaboration with the Manager and Overseer of the estate, and the observations in Tables II and III were made in collaboration with the Managers of the respective estates. Very occasionally there were slight differences of opinion as to the condition of a palm in which case a question mark was placed in the observation column and a decision made later on referring to previous and subsequent records. The Tables show that (i) observations at more frequent intervals than a month are desirable, to define more clearly the period at which the disease commences and at which diseased palms begin to recover. This point will be important when,


GRAPH SHOWING INCIDENCE OF DISEASE
No. OF PALMS AFFECTED
100
80
60
40
20
0
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.


RAINFALL CURVE
RAINFALL IN INCHES
15
12
9
6
3
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

in future, different control measures are put to the test. (ii) Palms suffering from Bronze Leaf Wilt may recover with change of conditions but this recovery is not necessarily permanent. Indeed there is evidence that palms recover in some cases for a few months only whilst in others they may recover several times depending on conditions but death is, nevertheless, inevitable in a very large number of cases. (iii) There is a definite seasonal variation in the incidence of the disease which is correlated with wet and dry seasons. *Vide* also the graph which is based on observations carried out on 208 palms on three different estates. Observations were also carried out on 162 palms on another estate but the field was abandoned after the 9th July because by that date as many as 134 of the palms had died of Wilt. The rainfall graphs are based on records kept on two neighbouring estates within a few miles of which the palms referred to in Table I were growing. There is such wide variation that only a general conclusion can be based on them, namely, that the wet season in both cases commenced in June.

Effect on Weeds.

In further support of the conclusion that drought is one of the main causes of the disease it has been observed that, when the type of soil coupled with agricultural malpractices render conditions very bad, grasses and other weeds fail to grow to any extent under diseased trees during the dry season. In the traces and where palms have died of Wilt the grasses and weeds thrive luxuriantly throughout the dry season. That this is not due to the effect of shade has been ascertained by observation on several occasions. Where a single high palm has survived the soil occupied by its root system is almost free of weeds. This is shown in Plate II. The weeds seen in front of the palm are growing in the drain and not on the bed. Furthermore, soon after the rains commence the weeds grow luxuriantly even in the shade. The soil in narrow traces which are as deeply shaded as the soil within the plantation need only be tested for soil moisture content and compared with that of the soil in the beds to eliminate all doubt on this point.

General Consideration.

Some of the palms which are shown in Table I to have recovered from the disease in 1928 have died during the dry season of 1929 whilst others have contracted the disease and recovered as they did last year. Unless some measures of control are worked out in the meantime the majority of those that have recovered last year and this year are doomed to die sooner or later within the next few years. Wilt disease develops to a slight extent when palms are comparatively young, in some cases only five years old. These undergo, therefore, an annual pruning of the lowermost leaves for several years until the palms come into bearing when the annual loss of leaves gradually increases from year to year with, of course, its adverse effect on the yield. The nuts in the axils of these lower leaves fall before they reach the stage of ripening. Sooner or later the palms reach such a size that the available soil cannot support them and they die of Wilt. The age at which the palms die depends on a number of factors such as seasonal rainfall, method of planting, type of soil and cultural operations. The effect of rainfall has already been discussed so far as it is possible to do so on the evidence available up to the present time. The question of soil types and cultural operations is discussed below.

Soil.

As previously stated ([1]) it is unlikely that the soils under Coconuts on which the disease occurs differ fundamentally as soil types from those on which sugar-cane is grown. As a general truth it can be stated that the poorer lands which supported sugar-cane in the past have been put under Coconuts because the former crop suffered very badly from blight caused by Froghopper (*Monecphora saccharina*). Futhermore, several young Coconut plantations are now in the process of becoming established in sugar-cane fields. It seems reasonable, therefore, to conclude that the findings of Hardy ([3-5]) and Turner ([7-9]) in their researches on sugar-cane soils in Trinidad will in the main become applicable to soils under Coconuts. Indeed, the writer wishes to acknowledge the fact that use has already been made of the results of the work of both these workers. Apart from the modifications in methods of cultivation which are discussed below there is no doubt that the main line of work in regard to the control of this destructive malady of Coconuts must have as its main object the means by which the amelioration of the soils can be accomplished. Most soils can be improved by cultivation, manuring with pen manure, liming when required, leguminous cover crops, draining, &c., but the all-important question in connection with Coconuts is whether, after the cost of such operations coupled with the time factor is taken into account, it can be considered not only an economic proposition but the best possible proposition. A change of crop has in some cases been found to be the best way out of the difficulty. The losses in Coconuts due to Wilt can be estimated, in terms of death, from estate records but this is, in terms of the crop yield, only a small fraction of the loss caused by this disease. The loss of one or two of the lower leaves of a Coconut palm through Wilt is hardly if at all noticed, yet this means the loss of a bunch of nuts. The writer appreciates the fact that there are some experienced agriculturalists who will not agree with his view in regard to the serious financial losses caused by Wilt. On the other hand, the only means of obtaining a reliable answer is by carrying out experimental trials on Coconut estates of which detailed records must be kept.

Cultivation and Drainage.

The question as to whether soil under Coconuts should be cultivated by ploughing or disc harrowing is one which needs to be considered hand in hand with the question of drainage. The writer has already expressed (1) the view that, in a good many cases, drainage is being rather overdone with the result that, even without cultivation a great deal of the top soil is washed down by rains into the drains and is lost. If then such systems of drainage are coupled with cultivation the loss by wash will be greatly increased. Other reasons against cultivation of Coconuts in Trinidad have already been stated in Part I (1). Observations during the last year have led the writer to conclude that by digging deeper and more frequent drains the planter is trying, sometimes with partial success only and at other times with disastrous results, to rectify with this one operation, which has its optimum limits, everything that is wrong including a serious mistake which was made at the time of planting the Coconut palms. The planters' aim is to induce a deeper rooting system and there is no doubt that this is accomplished up to a point. It is necessary to exercise care in discussing this important question of drainage because it is, up to a point, essential and there is no doubt that in some cases conditions would be improved by deeper draining. As already indicated this cannot be done beyond a critical point because no further benefit accrues but rather the opposite. It is impossible to induce Coconut roots to grow down to any depth into the stiff clayey subsoil which is often met at a depth of a foot or so below the surface and sometimes less. If then there is a limit, even with the most perfect system of drainage possible, to the depth range of the Coconut root system on these soils there is only one other alternative by which the root system can be increased in its range and that is by wider planting.

The above leads to the very logical conclusion that in Trinidad the Coconut palms are planted much too close. One can often observe a single palm or a small group of palms, much older than those found in plantations yielding good crops and not suffering markedly from Wilt in spite of the fact that no treatment whatsoever is given to them. The writer submits that the reason for this is that they have a wider range of soil in which their root system can grow without meeting with competition from roots of neighbouring palms. The argument advanced in favour of close planting is that the palms produce a canopy thereby reducing evaporation from the soil. That the deep shade under closely planted Coconut palms does reduce evaporation is readily admitted but it is obviously futile if it can be proved that the additional palms producing the shade take up more water for their upkeep and growth that would be lost if the soil was exposed to the sun. The photograph (Plate II) shows in the left foreground that, following the death of the palm through drought, the weeds have grown luxuriantly, whereas under the palm in the foreground the weeds have failed to thrive to any extent. Futhermore, the traces are generally narrower than the Coconut beds and are bounded on each side by a deep and wide drain which functions, in a good many cases, as the head drain for the beds. It follows, that the trace is better drained than the beds. One would expect the soil in the trace, therefore, to dry out quicker than that in the beds but this is not the case. When the beds are so dry that the heel of a boot can make little or no impression, in the trace it can be driven into the moister soil. Likewise the soil in the trace can be made to retain its shape as a ball whereas that in the beds is so dry that it crumbles in the hand. Such examples might be criticised on the crudity of the method but, nevertheless, they serve very well as field tests.

The best possible use that can be made of a mistake in the past is to turn it to advantage. This can be done in the case of too closely planted Coconut palms in Trinidad if the planters have the wisdom and courage to do so. If every other palm is cut down the roots of the remaining palms can then grow into the soil previously occupied. This soil would also be fairly rich in organic food material as the result of the decay of the roots of the felled palms. The distance of planting in a good many cases is 20 feet and the removal of every other one would mean a plantation with a distance of 40 feet between the palms in the beds. This might be considered excessive and a reliable decision on this point can again only be obtained as the result of experimental trials. In the meantime there are one or two points which tend towards a conclusion in favour of planting at a distance of 40 feet or even more. On really good Coconut soils in the East the distance of planting advocated is 30 feet by 30 feet. This means that the surface root range covers an area of 900 square feet. Few Coconut beds in Trinidad exceed 25 feet in width and to take this as an average is a liberal estimate. To arrive at 900 square feet as a surface area for each plant in a 25 foot bed the planting distance between the palms must be 36 feet. On the the other hand, Coconut roots in good soil, particularly in marine formations, grow down into the soil to several feet in depth. In Trinidad the effective root system is confined to the top 12-18 inches of soil. The extra four feet, therefore, suggested for Trinidad does if anything, underestimate the soil requirements of bearing Coconut palms.

Change of Drainage System.

It is the usual practice to plant Coconuts on the side of the beds (fig. 1.) so that while sugar-cane is being grown for the first few years the harvesting carts can be driven on to the beds without danger of seriously damaging the palms. In later years when sugar-cane can no longer be grown it is decided to change the position of the drain so that the palm assumes a position in the centre of the reformed bed. During the

WILT DISEASES OF COCONUT PALMS IN TRINIDAD.

Plate I.

Plate II.

Plate III.

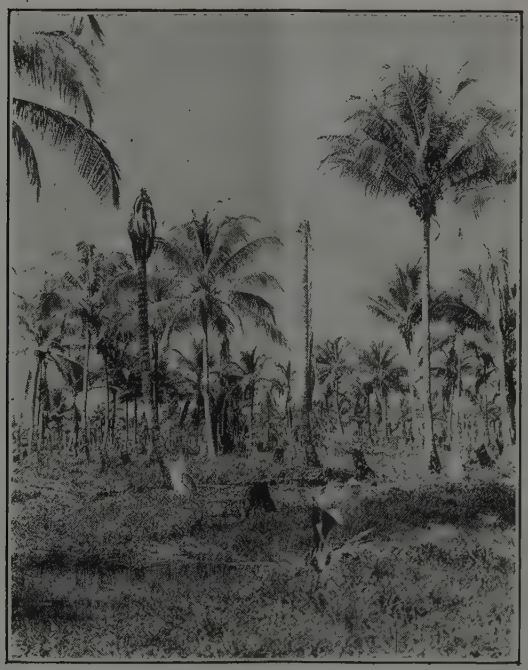


Plate IV.

first year the old drain which has been filled in with soil, coconut leaves, husks and other vegetable matter, functions as a subsoil drain, and no bad effects are shown (fig. 2). In the second year following the operation, however, the tissues of the leaves, husks, &c., have broken down with the result that there is, along the whole length of the bed a shallow trench with no outlet. This becomes in the wet season thoroughly waterlogged with its attendant evil results (fig. 3).

The reason for the change to the centre of the beds is possibly due to the fact that otherwise, when the drains are cleaned out periodically of weeds and accumulated soil from the beds, there is danger of the palm becoming undermined by the water which runs down the drains in the wet season. The better method of accomplishing the change in the position of the drain is that which was described in Part I ([1]). On the other hand, if the palms were planted about five feet

Fig. 1

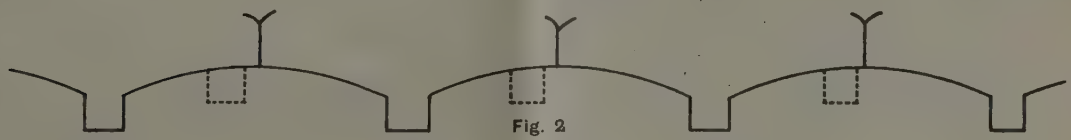


Fig. 2

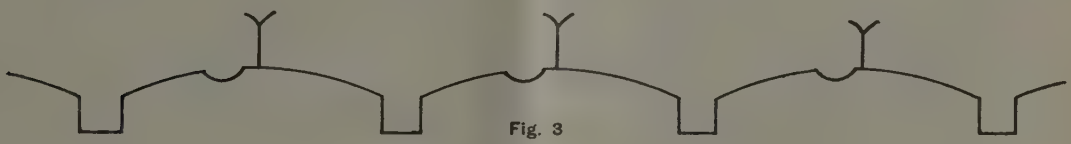


Fig. 3

from the drain and not on its very edge it is doubtful whether a change into the centre of the bed would be at all necessary or advisable. It is often the case that palms bend slightly towards the drain near which it is planted. This means that after a shower of rain a stream of water runs down the trunk on the side towards which the palm is leaning. If the drain is kept open it is in a good position to function to the best advantage for carrying away the surplus water, whereas if filled up it, after the soil and vegetable matter has sunk, is in the best place possible for waterlogging. Furthermore, a coconut palm like all other plants utilises to the very best possible advantage the conditions under which it is growing. Any sudden change is, therefore, fraught with danger.

Conclusion.

Further evidence has been put forward in support of the view expressed in Part I, namely, that Bronze Leaf Wilt is caused by a combination of factors including, the soil moisture factor which is to a large extent dependent on the tilth, texture, humus content, &c., of the soil, together with unsuitable and in many cases definitely injurious agricultural operations. Furthermore, as the result of extensive observations it is now possible to predict the death of Coconut palms some years before it takes place. The situation is serious on several estates at the present time. When, however, it is considered that the majority of bearing Coconut plantations on sugar-cane estates are still comparatively young and that the affection gets worse as the palms grow older, it seems reasonable to conclude that it is important to find out whether or not losses can be effectively reduced. The manner in which this can be done is by means of extensive trials of different measures of control, keeping records of the cost of the operations together with detailed observations of the conditions of the treated and untreated palms at regular and frequent intervals as well as cropping records. Whether the results of such an investigation prove that control of the disease is possible on an economic basis or prove completely negative they will, in either case, be the means of saving a considerable sum of money.

In addition to the urgent necessity for carrying out work in an endeavour to save the areas which are already planted up research work on soils might result in working out a technique by means of which it would be possible to decide what lands can and cannot profitably be planted up with Coconuts in the future,

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Explanation of signs used in Tables.

1B —One bronze coloured leaf.

2BY —Two leaves showing bronze to yellow colouring over whole surface.

1BY(½)—One leaf showing bronze to yellow colouring on the upper half only, the remainder of the leaf being normal green.

1BYT —One leaf showing bronze to yellow colouring near the tip only, the remainder being normal green.

3 YT —3 leaves showing yellowing at tips only, the remainder of the leaf being normal green colour.

Explanation of Plates.

PLATE I.—Bases of fallen leaves from palms affected with Bronze Leaf Wilt. Note the absence of any marked discolouration.

PLATE II.—Showing effect of palms on weed growth.

PLATE III.—Final stages of Bronze Leaf Wilt Disease in a palm of cropping age.

PLATE IV.—Showing serious losses caused by Bronze Leaf Wilt Disease.

TABLE I.

No. of Palm.	27. 2. 28.	5. 3. 28.	21. 3. 28.	20. 4. 28.	8. 5. 28.	11. 6. 28.	9. 7. 28.	14. 8. 28.	14. 9. 28.	25. 10. 28.	17. 12. 28.	
1 ..	2B hanging	1 fallen 1B hanging 3Y	Wilt	Wilt	Wilt	Wilt	Wilt	Dead				
2 ..	2B	2 fallen	1BY & 1G	2 fallen, 1BY	1 fallen	1 fallen, 1BY	1YT	1Y(½)	Healthy	Healthy	Healthy	
	1 G hanging	1 G hanging	1 hanging	1YT	1YT	1YT						R.
4 ..	1BY(½)	1BY(½)1YT	1BY, 2YT	1 fallen, 1BY, 1YT	1BY, 4YT	1B, 1BY	5YT	No colour	3Y(½)	Wilt	Wilt	
5 ..	Healthy	1BT. Healthy	2B. 2BY	4 fallen, 1YT	1BY, 2YT	1B, 2YT	2YT	2B, 2YT	1BY, 2Y(½)	Wilt	Dead	
6 ..	Healthy	1BY(½)2YT	1B, 1BY, 2YT	Wilt	Wilt	Wilt	1YT, improved condition	1Y(½)	3BY, 2YT	Wilt	Dead	
7 ..	1BY(½)	1BY, 1BY (½), 1YT	2BY(½), 1YT	No colour	1BY, 2YT	No record	1BY, 1YT	2Y(½)	2YT	1 fallen, 1YT	1BT, Healthy	
9 ..	1BY(½)	1BY(½), 1BYT	1B, 3YT	1 fallen, 1BY(½) 2YT	1BY, 2YT	1B, 2YT	1BY, 2YT	1Y(½)	3YT	2YT	Healthy	
10 ..	1B hanging	1B hanging	1 fallen, 2BY, 2YT	Wilt	Wilt	Wilt	Wilt	Wilt	Dead			
12 ..	1B hanging 2BYT	1B hanging 1BY(½), 2YT	1 fallen, 1BY 2YT	1B, 1BY, 1YT	2 fallen, 1 tip	2BY(½)	4YT	1Y(½), 1YT	4YT	2YT	1BY, Healthy.	
14 ..	1B hanging 6 green hanging (Poor type) Healthy.	Healthy	Healthy	Healthy	Wilt	Wilt	Wilt	Improved condition	Improved condition	Improved condition	Healthy	
16 ..	1BY(½)	1BY(½), 1BYT	1B, 3BY, 3YT	Wilt	Wilt	Wilt	Wilt	Dead				
17 ..	3BY(½), 1YT	2BY, 1 tip	2 fallen, 3YT	2 fallen, 1YT	Wilt	3BY	4B, 3BY	Wilt	Wilt	Wilt	Dead	
18 ..	Healthy	1YT	1 fallen	Healthy	1BY	1BY, 2YT	2BY	Wilt	Wilt	Wilt	Wilt	
19 ..	6BY, 3BY(½) Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead					
23 ..	3BY, 3BY(½) Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead				
24 ..	2BY(½)	2BY, 2YT	2 fallen, 1YT	Wilt	Wilt	Wilt	Dead					
25 ..	1B hanging 1BY, 2YT	3YT	1B, 2YT	2 fallen, 1YT	Wilt	1BY, 2YT	1B hanging 1YT	1B hanging	1B hanging	1YT	Healthy	R.
26 ..	Healthy	Healthy	1B, 1BY	2 fallen, 1YT	1BY	2BY, 2YT	2B hanging 1BY Wilt	1B hanging	2YT	4Y(½) hanging	Healthy	R.
27 ..	1BY Healthy	1B Healthy	Healthy	1 fallen 2B (Wilt)	1 fallen 1B	2YT	4BY(½)	1B, 1Y(½)	1B hanging 3YT	1BT	Healthy	R.
28 ..	3YB	No colour	2 fallen, 1BY, 1YT	2BY, 2YT ? fallen	1B, 2YT	2YT	1BY hanging 2YT	1B, 3BY 2Y(½)	4B hanging 3BY	Wilt	Dead	
29 ..	Wilt	Wilt	Wilt	Dead								
33 ..	Healthy	Healthy	1BY	1 fallen, 1BY	1B, 3YT	2BY, 2YT (Wilt)	1YT	1BY	1YT	Healthy	Healthy	R.
34 ..	Healthy	Healthy	1BY, 2YT	1BY	No colour	1YT	1BY(½), 4YT	Wilt	Wilt	Wilt	2Y?	
35 ..	Wilt	Wilt	Wilt	Wilt	Wilt	Dead						

TABLE I—CONTD.

No. of Palm.	27. 2. 28.	5. 3. 28.	21. 3. 28.	20. 4. 28.	8. 5. 28.	11. 6. 28.	9. 7. 28.	14. 8. 28.	14. 9. 28.	25. 10. 28.	17. 12. 28.	
38 ..	Healthy	5YT	1 fallen, 2BY, 1BY½ Wilt ?	3 fallen, No colour	Wilt	2YT, 1BY	1BY, 1BY(½)	4YT	3Y(½)	4Y(½)	Wilt	
39 ..	1BY (Healthy)	Healthy	1 fallen Healthy	1BY	1BY	2B hanging	1B hanging 1BY 2YT	2Y(½)	2YT	Healthy	Healthy	
40 ..	1BY Healthy	Healthy	1 fallen	1BY	Wilt	2BY, 2YT	3B hanging 1YT	3B hanging 1YT	3B hanging 2YT	3B hanging 1YT	Healthy	R.
42 ..	1BY(½) Healthy	1BY, 2YT	1 fallen, several YT	1 fallen, 1B, 1BY, several tips wilt	Wilt	3 fallen, 2B hanging	4BYT	5YT	6YT	3Y(½), 1BT	Healthy	R.
43 ..	Healthy	1B(½)	1 fallen	3 fallen, 2BY wilt	2BY, 2YT	5 fallen, 1BY	Wilt	Dead				
45 ..	2BY(½)	2B(½), 2YT	3BY, 1B Y(½) several YT wilt	4 fallen several YT	No colour	2BY, 3YT	1BY hanging 2BYT, 3YT	2YT	3YT	1BYT	1BYT Healthy	R.
46 ..	Healthy	1BY, 4YT	1 fallen, 1B, 1BY, several tips, wilt	2 fallen, 1YT	Wilt	1B hanging 2YT	3YT	1BY	No colour	4Y(½)	Wilt	
48 ..	Healthy	Healthy	4BY, several YT Wilt	4 fallen 2B, 1BY(½)	1B, 1BY	1BY, 1YT	1BY(½), 3YT	1 fallen	Wilt	Wilt	Dead	
50 ..	2B, 1BY(½)	1 fallen, 1B, 1BY(½)	1B, 1BY, 1BY(½) 2YT (wilt)	3 fallen, 1BY, 1YT	2B, 1BY	2B hanging 1YT	1B hanging 2BYT	1B hanging 2Y(½)	1B hanging 1B(½) 3YT	1BY, 1B hanging Healthy	Healthy	R.
52 ..	Healthy	Healthy	Healthy	Healthy	Wilt	Wilt	No colour	No colour	Healthy	Healthy	Healthy	R. affected slightly by little leaf.
55 ..	Healthy	4YT	4YT	2 fallen, 1BY, 1B Y(½) 3YT Wilt	Wilt	2B hanging 1YT	1B, 2BYT	2BT	Healthy	1B hanging Healthy	Healthy	R.
56 ..	1B, 2BY	2 fallen, 1B	1 fallen, 1BY	1 fallen, 1B, 1BY (wilt)	2 fallen, No colour	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy	R*
57 ..	4BY(½)	1B, 1BY, 1BY(½) 2YT, wilt	2 fallen, 2YT	3 fallen, 1BY	1 fallen, No colour	No colour	Healthy	Healthy	Healthy	Healthy	Healthy	R*
58 ..	1BY. T Healthy	Healthy	2B	2 fallen, 1BY	1B, 1BY(½)	1 fallen	1B hanging	1B hanging, 2YT	2BT	Healthy	Healthy	
59 ..	1BYT Healthy	1BY(½) 1YT	1 fallen, 1BY(½) 1YT	2 fallen, 1B, 1YT	1 fallen, 1B	No colour	No colour	2B(½), 3YT	2B hanging 4YT	Wilt	Wilt	
60 ..	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead					
62 ..	1B & 1 Green hanging Healthy	Healthy	Healthy	2 fallen, 1B, 2BY (Wilt)	1B, 2YT	1YT	No colour	Healthy	Healthy	Healthy	Healthy	R
63 ..	1BY(½) Healthy	Healthy	1B, 1YT	2 fallen, 2YT (Wilt ?)	2YT	No colour	No colour	Healthy	Healthy	Healthy	Healthy	R ?
64 ..	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead					
65 ..	1BY(½) Healthy	Healthy	1 fallen	Several fallen 2BY Wilt	Wilt	1YT	1B hanging 1Y(½)	1B hanging 2BY, 1Y(½)	Wilt	Wilt	Dead	
67 ..	Healthy	Healthy	1B	2B	2YT	1YT	No colour	2B hanging 3YT	4B hanging 4YT Wilt	Wilt	Dead	
69 ..	1BY(½) 3YT	Healthy	1 fallen, 2YT	Several fallen 2YT Wilt	2YT	2YT	2BYT	3BYT	6YT	2BT	Wilt	
71 ..	3BY(½)	No colour	2 fallen 1B, 2YT	3 fallen No colour	3BY wilt	2B hanging 2YT	5B(½), 6BY, wilt	Wilt	Wilt	Wilt,	Dead	
72 ..	Healthy	Healthy	Healthy	Healthy	1BY	No colour	No colour	No colour	2BY	Wilt	Dead	

TABLE I.—CONTD.

No. of Palm.	27. 2. 28.	5. 3. 28.	21. 3. 28.	20. 4. 28.	8. 5. 28.	11. 6. 28.	9. 7. 28.	14. 8. 28.	14. 9. 28.	25. 10. 28.	17. 12. 28.
74 ..	1BY(½), 1YT	1 BY, 2YT	1 fallen, 2YT	1YT	Wilt	3YT	3BY, 3BY(½) 1YT, wilt.	Wilt	Wilt	Wilt	Dead
75 ..	Healthy	Healthy	3YT	2 fallen, 1BY(½)	No colour	4YT	4BY, 3YT	Wilt	Wilt	Wilt	Dead
76 ..	2BY(½), 1YT	1B, 1BY, 2YT, wilt	2 fallen, 1BY(½), 1YT	Wilt	No colour	2YT	4YT	4Y(½)	3YT	2BY	No colour
77 ..	2BY	No colour	2 fallen, 1YB (Wilt ?)	3BY, 2YT Wilt	2 fallen, 2YT	1BY, 1YT	1B hanging, 1BY(½), 2YT	1B hanging	1YT	No colour	Healthy R.
78 ..	Healthy	Healthy	Healthy	2 fallen, 2BY, wilt	Wilt	4YT	5B hanging	4B hanging	3B hanging	2B hanging	Healthy
79 ..	1BY, 2YT	1BY, 2YT	1B, 2YT	2BY, 2YT Wilt	Wilt	3B hanging, 2YT	1YT	No colour	No colour	Healthy	Healthy R
80 ..	1B, 1BY, 3YT	No colour	2 fallen, 3YT	1BY 2BY(½) 1YT	1 fallen, 4YT	4BY, wilt	3YT	2BY, 3Y(½)	2YT	1BY	Healthy R
82 ..	No colour	3BYT	1 fallen, several YT	1 fallen, 1B, several YT Wilt ?	Wilt	2YT	3BY	1Y(½), 2YT	No colour	1BY	Healthy R
83 ..	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead				
84 ..	1BY, 3YT	No colour	1 fallen, 1BY, 1BY(½), several tips, wilt	Some fallen, 1B, 1YT	Wilt	3B hanging, 2YT Wilt	2 fallen, 2BY, 2YT Wilt	Wilt	Wilt	Wilt	Dead
86 ..	1B, 1BY, 2YT	No colour	1 fallen, 3YT	1 fallen down 1BY, several tips	1 fallen	1B hanging 3YT	3B hanging 1BY, 1Y(½) Wilt	Wilt	Wilt	Wilt	Dead
87 ..	1B, 1BY, 2YT	1 fallen	1 fallen, 3YT	1 fallen, 1BY several YT	1BY, 1YT	1B hanging	No colour	No colour	Healthy	Healthy	Healthy
88 ..	Healthy	Healthy	3YT	1BY(½) several tips	Wilt	No colour	No colour	1BY, 2YT	Healthy	Healthy	Wilt
90 ..	Healthy	Healthy	2YT	4 fallen, Wilt	Wilt	Wilt	3BY	Wilt	Wilt	Dead	
91 ..	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead		
92 ..	1BY(½)	1BY	1 fallen, 1YT	1 fallen, 1YT	Healthy	Healthy	Healthy	Healthy	Healthy	1BY, 2Y(½)	Wilt
94 ..	2BY(½), 1YT	1BY, 2YB(½), 1YT	1 fallen, 1B, 1BY(½) 1YT	2 fallen, 1BY	1BY	Healthy	Healthy	Healthy	3B hanging, 4YT, Wilt	Wilt	Dead
95 ..	1B, 1YT	1 fallen, 1YT	4BY, wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead		
96 ..	Healthy	Healthy	1YT	Healthy	Healthy	1YT	1 fallen, 1YT	4Y(½), 2YT	Wilt	Wilt	Dead
97 ..	2BY(½)	2BY, 1YT	2 fallen, 1BY(½)	1 fallen	Healthy	Healthy	Healthy	1B fallen, 1Y(½)	Healthy	Healthy	Healthy
98 ..	Healthy	Healthy	1 fallen, 1BY(½), 1YT	1YT	Healthy	Healthy	Healthy	1B fallen, 1Y(½)	Healthy	Healthy	Healthy
100 ..	Healthy	1BY, 2YT	1 fallen, 3YT	4 fallen (Wilt)	Wilt	Wilt	Wilt	Wilt	Dead		
101 ..	1BY, 3YT	1 fallen, 1BY(½) 2YT	3B, 1BY(½)	2 fallen, 1B	1YT	3YT, 1B, hanging	1B hanging, 3Y(½) 1YT	2YT	Wilt	Wilt	Dead
102 ..	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Dead		
103 ..	Healthy	1BY, 3YT	1 fallen, wilt	3 fallen, wilt	Wilt	Wilt	Wilt	Wilt	Dead		
104 ..	1BY	1 fallen, No colour	1BY, 3YT	2 fallen, 1BY	Wilt	Wilt	Wilt	Wilt	Dead		

TABLE II.

No.	24. 4. 28	9. 5. 28	15. 6. 28	17. 7. 28	15. 8.28	17.9 28	16.10.28
12	Several fallen 1B hanging 1BY 1YT (Wilt)	1B hanging 1YT	1B hanging 1B(½)	1B hanging 1BY 1BY(½)	1B(½)	1B(½)	Healthy
19	1B, 1BY, 1BY(½) 1YT (Wilt)	1B	2B hanging 1YT several fallen	Several fallen 1B 1YT	1B hanging 1BY	1B hanging	1B hanging Healthy
29	3 fallen, 1YT	2BY	Several fallen (Wilt)	1BY	Several fallen	No change	Healthy
35	Several fallen 6YT (Wilt)	6YT	2B(½), 2YT	1B(½), 1YT	2YT	2YT	Healthy Cropping
78	1BY	1BY(½)	1B, 3BY (Wilt)	Several fallen	1BY	1BY	1BY Healthy
97	Several fallen several YT (wilt)	1BY	Several YT	1 fallen several YT	Tips on 17. 7. 28 dried up. No further advance	for 15. 8. 28	Healthy

TABLE III.

No.	24. 4. 28	9. 5. 28	8. 6. 28	15. 8. 28	13. 9. 28	31.10.28	17. 12. 28
17	1 fallen, 1B 1(½) 1YT (Slight wilt)	1B, 1BY(½)	No colour	No colour	3BT	1BY, 1BT no wilt	Healthy
44	1 fallen, 2B several YT (wilt)	3YT	2B, 2B hanging 1YT	2BY, 1YT	3B, 1YT	5B and 1 green hanging	Healthy
65	Several fallen 2YT (wilt)	1BY	No colour	Healthy	healthy	healthy	Healthy
83	2 fallen, 1B, 1BY(½) (Slight wilt)	2YT	5YT	Healthy	healthy	healthy	Healthy
86	Several fallen 3B(wilt)	No colour	Healthy	Healthy	healthy	healthy	Hea thy